Dairy Cattle Feeding and Management

The future of dairy husbandry is in good hands

Dairy Cattle Feeding and Management

FOURTH EDITION

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JOHN WILEY & SONS, INC., NEW YORK
LONDON

fourth edition
Second Printing July 1960

Library of Congress Catalog Card Number 54-6129

IN THE UNITED STATES OF AMERICA

Preface

The third edition of *Dairy Cattle Feeding and Management,* published before the second World War, met with general favor among teachers and other workers in the dairy-production field. Since its publication, however, great changes have taken place in the science of dairying, which have made it necessary to revise many chapters and to add others in order to keep pace with these changes.

Artificial breeding and its many inherent problems, the digestibility of feeds, especially those related to the microorganisms in the rumen, the general use of grass silage and grassland farming, the new types of buildings and equipment used on the dairy farms, the mechanization of farms and dairies, the improved method of milking, and many other changes too numerous to mention have, for the most part, been developed since the publication of the third edition.

In the writing of the present edition the latest literature on the various subdivisions of the subject has been used, and, when the author of any statement was known, credit was given in the footnote. The chapters have been rewritten and brought up to date, and six entirely new chapters have been added. In addition, a list of references for further study is included at the end of each chapter, so that students who desire may pursue their studies on the various subjects, or the instructor may use these references for outside assignments.

The object of the authors of this book has been to bring together in a compact and teachable way the more important findings of investigations in the field of dairy husbandry. It has not been the purpose to include the results of every experiment that has been published on the various subjects discussed, but rather to present the best information available at the present time. No

doubt many worthy articles will be entirely omitted, but it is impossible to include everything in a book of this size

Although the book was written for the student in dairy-cattle feeding and management, it is believed by the authors that practical dairymen, herdsmen, inseminators, and all others in the dairy field will find the material presented useful in their work

The first edition was the work of Carl W Larson and Fred S Putney The second and third editions were revisions by Harry O Henderson, who, not finding time to make the revision for the fourth edition without help, asked the help of Paul M Reaves as junior author Many of the new ideas incorporated in this edition were contributed by the junior author, but the authors have worked closely together with the one object in mind, namely, to make this a teachable and useful text

H O HENDERSON

Morgantown W Va
December, 1953

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Development of Dairying

Dairy-cattle husbandry includes all phases of caring for the dairy cow, such as feeding, breeding, and management. The importance of milk in the human diet is known by everyone. A well-known authority in nutrition has said that "without milk the white race cannot survive." Since the health and well-being of the people of this nation depend upon the consumption of large quantities of milk and its products, the dairy farmer is challenged to produce an adequate supply of milk as economically as possible in order that the entire population may consume an abundance of this health-giving food.

To accomplish this the dairy farmers must do an even better job of dairy farming. They must so feed and care for their herds that the production of milk will continue to increase. The annual production of the dairy cow in the United States averages approximately 5300 pounds of milk and 210 pounds of butterfat; the more than a million cows on test in dairy herd improvement associations produce on an average 9172 pounds of milk and 370 pounds of butterfat, thus showing that there is great room for improvement.

Research helps show the way. The following statement was made in the United States Department of Agriculture, Bureau of Dairy Industry Report for 1951. "The dairy industry owes much of its present economical and nutritional importance to the result of research in many different fields of scientific effort. Animal husbandmen, agronomists, plant and animal geneticists, bacteriologists, chemists, entomologists, physiologists, engineers, nutritionists,—and a host of other scientific and practical workers—have all made a contribution to the development of this great industry. Undoubtedly, further progress by the dairy industry

will also depend upon research both in the field of fundamental science and in the application of results"

RESEARCH IN DAIRY HUSBANDRY

More research results are needed in order for the dairymen to continue to increase production and to produce milk more economically Research results have aided and should continue to aid in the following fields

(a) Feeds and Feeding One of the limiting factors in increased production of milk is insufficient high-quality feed More attention must be given to the production of more and better pastures and to the growing and preserving of forage crops in their best nutritive form either as silage or hay Application of research results to the fundamentals of the feeding of dairy animals of all ages points the way to the most efficient use of available feeds Unbalanced rations and improper feeding methods are responsible for lower production and for lowered utilization of the nutrients in the feeds

(b) Herd Health Much is known about preventing and controlling many of the infectious and other diseases of cattle Federal and state regulations are set up to help prevent the spread of some of these diseases It is however in the long run the responsibility of the dairyman to develop a management program to protect and care for his own herd Reproductive difficulties and udder troubles probably are the two greatest health problems troubling the dairyman and both are at least partly due to faulty herd management Research has shown that with good management practices many of these problems can be controlled

(c) Breeding Although great improvement in the average production of the dairy cow will result from better feeding methods and from maintaining healthy herds continued improvement must result from breeding cows whose strain will make for increased milk production The application of the results of research to dairy cattle breeding will improve the inherent ability of cows to produce larger amounts of milk and butterfat The artificial breeding of dairy cattle is a new approach to increasing production of dairy cows It is a means of bringing good in

heritance to the great mass of dairy cattle scattered in all parts of the country.

(*d*) **Milking.** With the development of better cows comes the necessity of handling them more carefully. The milking of a cow is governed by certain specific rules, predicated on scientific facts. If these rules are followed, greater production will result. Managed milking not only causes the cow to produce more milk but it helps to protect the udder from mastitis and other ailments.

(*e*) **Labor-Saving Equipment and Methods.** The labor cost of milk production represents a higher per cent of the total cost than it has in the past. To compensate for this, labor-saving equipment and labor-saving methods must be used. Efficiently planned buildings and labor-saving equipment and methods are making it possible for a man to care for more cows and to produce more milk per hour of labor. Research is helping develop such labor-saving methods and equipment.

Continued research in these and other fields is needed.

THE DAIRYMAN

Many other factors enter into the task of increasing milk production economically. Many of these are closely connected with the dairyman himself. He should be a man with a sincere love for dairy cows; one who knows how to feed and care for them so that he will get the greatest amount of milk at the smallest possible cost. He must be gentle and patient and should not expect results too quickly. Above all, he should be careful with details, watching carefully such details as the health of the individual cows, the regularity of feeding and milking, the cleanliness of the cows, the barn and the utensils, the method of milking, and the many other requirements for efficient milk production.

IMPORTANCE OF DAIRYING

More than 80 per cent of all the farmers in the United States are involved in the feeding, care, and management of dairy cattle. Approximately 25 million dairy cows in this country produce milk for human consumption or for the manufacture of dairy products.

Because of the nature of dairy products, especially milk, the producer and consumer are equally interested in maintaining an adequate and wholesome supply of these products There is a daily demand for milk or some of its products by every family There are no substitutes for milk Children must have it for growth, adults require it for health, and invalids as well as old people must turn to it as a means of prolonging their lives

Dairy husbandry is of comparatively recent origin Milk, however, has been used as food for man from the earliest times As far back as history records, milk and some of its products, especially butter and cheese, were used as articles of food The book of Genesis contains records of their use, and excavations reveal the presence of the bones of dairy animals among ancient remains of human life Through all the ages dairying has played a part in the agriculture of the various nations, but it did not begin to attain an important status until about 1850

Nature intended the cow to produce enough milk to feed her calf, but man has developed this function to such a point that frequently a single cow produces sufficient milk to feed many calves As land was taken up and the herder was not permitted to move his cattle from field to field when new pasture became necessary, he was obliged to adopt a more complete system of feeding in order to obtain increased milk production

By far the greatest proportion of milk produced in this country is from the small dairy herd It is possible to produce milk as a side line and to sell it cheaper than that produced in the specialized dairy, where all labor must be hired and where good marketable crops must be fed In a dairy of few cows, much of the roughage, such as stover, straw, and hay, that may be discolored by rain or otherwise made unmarketable, can be used to a better advantage than by putting it on the market Moreover, a few cows may often be milked and cared for without the cost of hired labor

Because of the competition from small dairy herds on general farms, the larger specialized herds have been developed under certain definite conditions However, with the increased demands for milk produced under exceptionally clean conditions from healthy cows, the specialized dairy has gradually replaced the system of milk production as a side line, especially in those sections where milk is produced primarily for consumption as

fluid milk. Special equipment and methods are needed for producing clean, sanitary milk. Such milk is produced at a somewhat higher cost, but the consumer willingly pays for the improved quality.

A few other animals besides the cow have been used for the production of milk. The most common of these is the goat, though the mare, the ass, the ewe, the water buffalo, and other animals have been used in other countries. In the United States the goat is the only animal besides the cow that is used to produce milk commercially. Goat's milk is produced primarily for invalid feeding, although it is used to a limited extent for other purposes.

EXTENT OF THE DAIRY INDUSTRY

Although the dairy industry in the United States developed slowly at first it has increased rapidly during the past 100 years. Table I shows the amount of milk produced and its utilization.

TABLE I

Milk Production and Utilization *

Purpose for Which Used	Whole Milk Used, 1,000,000 lb.	Percentage of Total Milk	Amount of Product Produced, 1,000,000 lb.	Amount Consumed per Capita
Fluid milk and cream				
In cities	45,999	37.3		180 qt.
On farms	12,451	10.1		
Butter				
Creamery butter	27,980	22.7	1395	10.8 lb.
Farm butter	5,364	4.3	264	
Cheese	11,681	9.5	1172	7.5 lb.
Evaporated and condensed milk	6,940	5.6	3136	
Ice cream	6,269	5.1	510	13.6 qt.
Dried whole milk	991	0.8	125	....
Fed calves	3,382	2.7	.	....
Other uses	2,324	1.9	. .	....
	123,381	100.0		

* United States Census of Agriculture, 1950.

The number of cows and heifers 2 years old and over kept for milk is approximately 25 million The number of cows, the average production per cow, and the total milk production by states are given in Table II, arranged according to number of dairy cows per state

Although the United States has more dairy cattle than any of the European nations the number is not so large in proportion to the area as in some European countries, nor is the production of the cows so high The dairy industry in the United States is, however, one of the largest and most profitable branches of the farm business About one fifth of the total value of farm production comes directly or indirectly from the dairy cow The growth of the dairy industry in the United States during the past two decades has been greater than during other similar periods This has been due largely to the fact that the consumption of dairy products has increased about 25 per cent during that time This increase in consumption has been brought about to a large extent by a better understanding of the high dietary value of milk and by the higher standard of living resulting from greater purchasing power of the average person

The increased efficiency in the production of milk has also been remarkable The average milk production of the cows in the United States has increased in the past 25 years more than 1200 pounds per cow Since 1840 the number of cows and the total production has been steadily increasing Although production per cow has increased the number of cows per 1000 population has gradually decreased (Table III) In 1950 there were only about 80 per cent as many cows per 1000 people as in 1930

This increase in production has been brought about by the adoption of more efficient methods Dairymen have a better understanding of the problem of feeding Also they are culling their herds more closely raising the heifer calves from only their better cows and selling the lower producing cows

REASONS FOR AND AGAINST DAIRY FARMING

There are several reasons why dairy farming has reached its present place in the agriculture of our country In the first place, milk is an excellent food and cannot be replaced in the diet with

TABLE II

NUMBER OF MILK COWS BY STATES, AVERAGE PRODUCTION PER COW, AND TOTAL PRODUCTION, 1950 *

Rank	State	Number of Cows, thousands	Milk Production per Cow, pounds	Total Production, million pounds
1	Wisconsin	2,306	6770	15,612
2	Minnesota	1,371	6020	8,253
3	New York	1,366	6590	9,002
4	Texas	1,171	3391	3,970
5	Iowa	1,088	5461	5,940
6	Ohio	1,013	5480	5,551
7	Michigan	968	5971	5,779
8	Pennsylvania	964	6160	5,938
9	Missouri	939	4711	4,423
10	Illinois	925	5601	5,180
11	California	813	7411	6,024
12	Indiana	705	5050	3,560
13	Tennessee	598	3911	2,338
14	Kansas	590	4670	2,755
15	Oklahoma	588	3659	2,152
16	Kentucky	583	4040	2,355
17	Mississippi	465	3000	1,395
18	Virginia	463	4850	2,131
19	Nebraska	449	4870	2,187
20	Arkansas	402	3281	1,319
21	Alabama	388	3610	1,408
22	North Dakota	375	4670	1,751
23	North Carolina	374	4459	1,668
24	Georgia	365	3640	1,329
25	South Dakota	333	4203	1,402
26	Washington	302	6639	2,005
27	Louisiana	266	2550	678
28	Vermont	262	5839	1,530
29	Maryland	235	5601	1,316
30	Oregon	219	5979	1,310
31	West Virginia	216	4081	881
32	Idaho	194	6209	1,205
33	Colorado	185	5300	980
34	New Jersey	159	7269	1,158
35	South Carolina	158	3990	630
36	Florida	136	4199	571
37	Massachusetts	120	6401	768
38	Maine	115	5620	646

TABLE II (*Continued*)

Number of Milk Cows by States, Average Production per Cow, and Total Production, 1950 *

Rank	State	Number of Cows, thousands	Milk Production per Cow, pounds	Total Production, million pounds
39	Montana	114	4960	565
40	Connecticut	107	6499	696
41	Utah	105	6469	697
42	New Hampshire	61	5601	342
43	New Mexico	55	4100	226
44	Wyoming	50	5349	268
45	Arizona	46	5801	267
46	Delaware	35	5231	183
47	Rhode Island	20	6899	138
48	Nevada	17	6050	103
		22,779		120,555

* United States Census of Agriculture, 1950.

TABLE III

Production Statistics, 1840–1950 *

Year	Milk Cows on Farms, thousands	Average Milk per Cow, pounds	Total Milk Produced, million pounds	Farm Cows per 1000 People
1840	4,837			287
1850	6,385			278
1860	8,586			276
1870	8,935			234
1880	12,443			251
1890	16,512			264
1900	17,136			237
1910	20,625	2902	59,854	225
1920	19 675	3964	77,992	203
1930	22 443	4510	99,705	205
1940	24,940	4625	109,502	190
1950	24,573	5292	120,555	163

* United States Census of Agriculture, 1950

out considerable difficulty; in the second place, dairy cows produce food more economically than any other kind of livestock; and, in the third place, with dairy farming the fertility of the soil can be maintained more readily than with any other type of agriculture. Furthermore, dairying is a stable form of agriculture and gives quick and regular returns.

In pointing out the disadvantages of dairying it may be said that good labor is hard to obtain, a large amount of capital is needed to start a specialized dairy business, and much risk is involved.

Milk as a Food. That milk is an excellent food, especially for growing children and invalids, has long been recognized, but the reason for this was not fully appreciated in the past. It has been known for a long time that the solids of milk are present in just the right proportion for nutrition and that milk is highly digestible and palatable. It has been found, however, that more than these essentials must be considered in the diet. We know now that not all proteins are of equal value, since some of them do not contain all the important amino acids that the body requires. The proteins of milk, nevertheless, are quite complete, and when milk is fed with the cereals it supplements their proteins adequately.

The diet must contain two additional factors: namely, sufficient mineral matter and the vitamins. Milk contains all the important minerals needed by the body, with the possible exception of iron and iodine. It is particularly rich in calcium, which is the element most likely to be deficient in the ordinary diet. A deficiency of minerals causes poor teeth and other bodily ailments.

Milk also contains the important vitamins which are necessary for the growth of the young and the well-being of the adult. No other food, except green leaves, contains all the vitamins, and man must therefore depend largely upon milk for his supply of these important elements.

For these reasons, milk is one of the most important food substances and must be supplied in liberal amounts. It has been said that no nation that was not a great consumer of milk has ever become a great world power, and also that our country cannot maintain its present position as a world power without the continued extensive use of milk.

Dairy Cows as Efficient Producers of Human Food. Of the common domestic animals, the cow is the most economical producer of human food A comparison of the dairy cow with other animals as to efficiency in the production of human food is given in Table IV

TABLE IV

HUMAN FOOD PRODUCED BY ANIMALS FROM 100 POUNDS OF DIGESTIBLE MATTER CONSUMED *

Animal	Marketable Product, pounds	Edible Solids pounds
Cow (milk)	139 0	18 0
Pig (dressed)	25 0	15 6
Cow (cheese)	14 8	9 4
Calf (dressed)	36 5	8 1
Cow (butter)	6 4	5 4
Poultry (eggs)	19 6	5 1
Poultry (dressed)	15 6	4 2
Lamb (dressed)	9 6	3 2
Steer (dressed)	8 3	2 8
Sheep (dressed)	7 0	2 6

* From *Feeding of Farm Animals* Jordan

From 100 pounds of digestible matter consumed, the cow yields 139 pounds of milk 18 pounds of which is edible solids, practically all digestible On the same basis, the pig returns 25 pounds of marketable product of which 15 6 pounds is edible The pig and the hen are the greatest competitors of the dairy cow in the production of human food Both, however, require a different kind of food from the dairy cow, which consumes vast quantities of roughage, such as hay, straw, stover, and similar rough feed that would often go to waste otherwise The pig and the hen must have an abundant supply of grain and cannot utilize large quantities of roughage

Both the sheep and the steer, on the other hand, are adapted to utilize roughage, but the dairy cow returns about 6 times as much edible solids in her milk, for each 100 pounds of digestible nutrients in the feed consumed as the sheep or the steer yield in their carcasses and the cow still remains to continue production for 2 to 6 years longer This fact accounts, no doubt, for the

prominent place held by the dairy cow in intensive farming and by the steer in extensive farming. It also accounts for the decrease in the number of beef cattle in the country as the population increases and the size of the farm decreases, and for the accompanying increase in the number of dairy cattle. The dairy cow fits into an intensive system, and is the chief producer on the very high-priced land of Holland and Denmark.

Relation of Dairying to Soil Fertility. Dairy farming, perhaps more than any other system of farming, makes it possible to conserve the fertility of the land and even to build up the soil. This is especially true in intensive dairying, when some of the grains are purchased, and even more so when butter is sold off the farm. Such feeds as wheat bran, linseed meal, and cottonseed meal, which are commonly purchased for dairy cows, are rich not only in nitrogen but also in phosphoric acid and potash. The amounts of the fertilizing constituents contained in a few of the common feedstuffs, together with their value per ton, based on the normal prices of the fertilizer constituents, are shown in Table V.

TABLE V

FERTILIZING CONSTITUENTS OF 1000 POUNDS OF MATERIAL AND ITS VALUE PER TON

	Feeding Constituents in 1000 Pounds			
Feeding Stuff	Nitrogen, pounds	Phosphoric Acid, pounds	Potash, pounds	Value per Ton *
Alfalfa	23.8	5.4	22 3	$12.73
Clover hay	20.5	3.9	16 3	10.53
Timothy hay	9.9	3 1	13 6	5.89
Corn silage	3.4	1.6	4 4	2 06
Corn meal	14.9	6.1	3.7	7 22
Gluten feed	40 6	6.2	2 3	17 36
Wheat bran	25 1	29 3	16.1	15 92
Wheat middlings	27 7	21.1	11 8	15 32
Cottonseed meal	63.7	26 6	18 0	31 18
Brewers' grains (dried)	42.4	9 9	0 9	19 34
Oats	19.8	8.1	5 6	9 67
Linseed meal	54.2	17 0	12.7	25.46

* Nitrogen figured at 20 cents, phosphoric acid at 7 cents, and potash at 5.5 cents, per pound.

FIG. 1 A profitable dairy herd, 1951 herd average on 2-times-a-day milking, 12,294 pounds of milk and 545 pounds of butterfat.

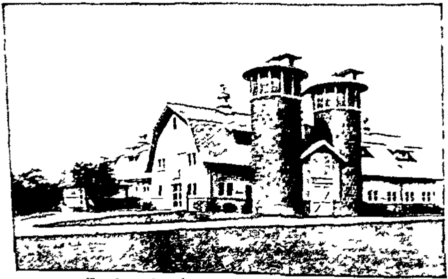

FIG. 2. A dairy barn with attractive surroundings.

Table V shows that whenever a ton of hay or straw is sold off the farm it takes with it a certain amount of soil fertility which must be replaced in some manner if the farm is to maintain its fertility. Where dairy farming is practiced, usually all the hay, straw, and grain are fed on the farm, and very often large amounts of high-protein feeds, such as cottonseed meal and linseed meal, are purchased for supplementary feeds. These add materially to the fertility of the soil, and when these and the homegrown feeds are fed to the dairy cow, about 70 per cent of fertilizer value can be restored to the farm in the form of manure. The selling of milk, and more especially of butter or cream, does not materially reduce the fertility of the soil.

In general, on farms on which no livestock is kept, the soil fertility is not maintained. It is not necessary to keep livestock in order to maintain fertility, but livestock farms are almost universally in a higher state of production than other farms. This is accounted for by the fact that manure is a by-product that cannot usually be marketed, whereas the maintenance of fertility by commercial fertilizers requires a direct cash outlay.

Sure and Regular Returns. Of all the farm occupations, that of dairying gives the surest and most regular returns. In the raising of beef or of grain, the return comes but a few times during the year, but with dairying the returns are steady. There is always a market for dairy products. It is true that the returns at times may not be as great as they are with other forms of livestock, but on the whole they vary less than with any other agricultural product.

With the development of good roads and with increased transportation facilities, dairying is spreading to all parts of the country.

The Labor Problem. The labor problem of a dairy farm is greater than in some other forms of agriculture, because of the fact that the work has to be done regularly each day, so that it is sometimes considered monotonous. Furthermore, more careful and skillful men are required than for many other lines of work. These limitations restrict the number of men available for the dairy farm, and also require that they be selected from a class who are paid more than ordinary laborers.

These disadvantages are well known, but there are other factors which tend to make the labor on the dairy farm more desirable. Whereas in many other forms of agriculture and industry employment is uncertain and quite irregular, on the dairy farm it is certain and continuous throughout the year. A workman, for example, working only one half the year, will seldom accumulate much property, neither will the farmer whose productive labor is confined to a few months of the year, as is true where a single crop is grown for market. Dairy farming gives the farmer an opportunity to use his time regularly. Members of his family may also find work adapted to their age and strength.

Even though the wages may not be so high as in some other occupations, nevertheless they are paid regularly and at the end of the year may amount to more than in other less regular types of work. Furthermore, many dairy farm workers are furnished a house, garden, milk, and other extras that workers in many other types of work do not receive. The advantages of living in the country cannot be overlooked.

The objections raised to long hours and to the steady, regular work may be partially overcome by giving the help regular time off each week and by the use of labor saving devices. For example, milking by machine is not considered nearly so laborious as milking by hand. Dairy help that truly likes dairy cows will not object to having more regular work than other laborers. All things considered, many of the so-called drawbacks to farm labor disappear or turn to advantages.

Capitalization and Risk. It requires a large amount of capital to start in the dairy business. The farm, the up-to-date barn, a good herd of cows, the equipment necessary for the farm and barns, require a great deal of capital. Also, there is the cost of feed and labor to keep the farm in operation. The risk involved in the operation of a dairy farm is considerable. Because of poor feeding or poor breeding methods, cows may develop diseases or may fail to produce sufficient milk for a profitable enterprise. For these reasons, it is not often advisable for a beginner to go extensively into the dairy business without some previous experience. It is usually better to grow into it, as one can do with a minimum amount of financial outlay. There is profit in the dairy business for the experienced man who has a good herd of

dairy cows and pays attention to the details of feeding, breeding, and management

PUREBRED DAIRY CATTLE

For those who have sufficient capital and know the methods of breeding, the raising of purebred dairy cattle offers a special opportunity Most of the dairy cattle in this country are grade animals As dairymen are constantly seeking to improve the production of this class of cattle, higher-producing purebred animals are needed to furnish the necessary breeding stock Perhaps the greatest development of the industry, as far as the animals are concerned, will be brought about by the use, in the grade herds, of bulls that will increase the herd production The value of a good bull can hardly be overestimated, as the producers of milk and dairy cattle are rapidly learning They are willing to pay high prices for good breeding stock There has always been a demand for good purebred animals, and this demand will probably always continue Therefore, the dairyman who can produce not only good milk but also high class livestock, and who can properly feed, show, and market the animals, can establish an especially desirable business An addition to the purpose of producing milk, the raising of purebred cattle is a separate enterprise

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2

The Components of Plants and Animals

ELEMENTS OF ANIMALS AND FEEDS

Of the many chemical elements now known, only eighteen are important as far as plant and animal life is concerned. Six of these elements (namely, oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus) make up 98.5 per cent of the plant or animal, the others occur in minute amounts varying from mere traces up to 0.5 per cent. These, in order of the amount found in the animal body, are potassium, sulfur, sodium, chlorine, magnesium, iron, iodine, fluorine, silicon, zinc, nickel, cobalt, copper, manganese, and arsenic. Some of these, though found in very minute quantities, are nevertheless necessary for life and well being. Others do not seem to have any known function.

COMPOUNDS

The elements named above combine to form a great many different compounds. These compounds can be divided into five great classes, as follows: water, ash, crude protein, carbohydrates, and fat, which is also called ether extract. Frequently, the carbohydrates are further divided by the chemist into nitrogen free extract and crude fiber. The following diagram will show how these compounds of the plant are divided during analyses. The water and ash are incombustible, the remaining compounds are combustible.

It is necessary to study these compounds before we can understand how they can be used by the animal body.

All feeding stuffs consist of

- Water
- Dry matter
  - Ash
  - *Organic matter*
    - Protein
    - Carbohydrates
      - Nitrogen-free extract
      - Fiber
    - Fat or ether extract

Water

Water, composed of hydrogen and oxygen, is a necessary compound of plants and animals. Growing plants contain as much as 70 to 80 per cent water, and even the bodies of animals are 70 to 90 per cent water. Water has several important functions in the animal body. It gives elasticity and rigidity to the supportive tissue of the animal, helps to dissolve the food, acts as a carrier of food and waste, helps to maintain the osmotic pressure of the body, and prevents extensive changes of temperature. It also has the power to dissociate into hydrogen ions and hydroxyl ions, with the result that it readily unites with many types of compounds. Any interference with the normal amount of water, in either plants or animals, produces disastrous results. Water, therefore, should always be supplied to livestock in large amounts.

Dry Matter

If a substance is heated to a temperature at or above that of boiling water until it ceases to lose weight, the remaining residue is known as dry matter. The loss of weight represents the moisture or water. A small amount of moisture, however, is still held in the dry matter. Dry matter is divided into organic matter and ash or inorganic matter.

Ash or Mineral Matter. When dry matter is burnt the organic matter can be burnt out, leaving what is known as ash or mineral matter. There is considerable ash in all the common feeding stuffs. In the animal the dry matter of the bones consists largely of ash, whereas the dry matter of the rest of the

body contains, on the average, about 7 1 per cent ash* The analysis, however, does not tell how the inorganic matter is distributed in the body The important minerals which are most likely to be lacking in the animal body are calcium, potassium, sodium, iron, phosphorus, chlorine, fluorine, iodine, sulfur, copper, cobalt and magnesium Silicon, manganese, nickel, and zinc are usually present in sufficient amounts

The functions of the minerals in the animal body are numerous They furnish material for the formation of new tissues, especially that of the skeleton and of the mineral part of milk Minerals are especially important for young, growing animals, and for lactating cows

The minerals help to maintain the osmotic pressure The cells of the various body tissues draw their nourishment from the lymph, from which they are separated by cell walls These walls have the nature of a semipermeable membrane In order to maintain normal conditions in the protoplasm of the cells, the osmotic pressure of the lymph, and therefore that of the blood from which it is derived, must be maintained approximately constant. The constant osmotic pressure is due largely to minerals contained in solution

The minerals help maintain the necessary ionic concentration in the body Certain important reactions in the body will not take place unless the proper ionic concentration is maintained Ptyalin, for example, is very sensitive to acid, but pepsin is most active when the reaction is slightly acid The different minerals dissociate and yield the desired ionic concentration

The minerals help maintain the neutrality of the body The body katabolism is continually producing acids, especially carbonic, phosphoric, and sulfuric, which tend to increase the acidity of the blood These are in part neutralized by the ammonia produced in the katabolism of the proteins, and in part by salts in the blood serum, especially the sodium phosphate and bicarbonate, which play an important part in maintaining its neutrality

The minerals aid in respiration Iron is an essential part of the hemoglobin, by means of which the oxygen is distributed through the body Iodine also is an essential constituent of thyroxine, an

* *The Nutrition of Farm Animals*, Armsby

important hormone secreted by the thyroid gland, which influences the rate of metabolism of all body cells.

The minerals are also necessary in putting certain materials into solution. Certain proteins, for example, are soluble only in dilute salt solutions. Some minerals also aid in digestion, especially of fats and proteins, and others are useful in protein and carbohydrate metabolism. They have the power to dissociate with the formation of ions that possess the power of conducting electric currents and are in this way very closely related to the chemistry of life.

Organic Matter

The chemist determines the organic matter by taking the difference between the dry matter and the ash. Organic matter is divided into three groups: protein, fat, and carbohydrates.

Protein. The crude protein of feeding stuffs is not determined directly by the chemist. The usual method of analysis is to determine the amount of nitrogen, and then to multiply this amount by the factor necessary for the particular feed. The factor most commonly used is 6.25.

Classification of Proteins. The proteins have been classified, not according to their nutritive properties, but according to certain characteristic chemical properties, particularly that of solubility. The classification is as follows:

A. Simple proteins. These are naturally occurring proteins, which, on being treated with enzymes or acids, break up only into amino acids or their derivatives.
   1. Albumins. These are soluble in pure water and coagulable by heat. Egg albumin, lactalbumin, and serum albumin are the most important ones, but others are found in small amounts in some of the common grains and legume seeds.
   2. Globulins. These are insoluble in pure water, but soluble in neutral salt solutions. Globulins are found in blood, in milk, and in many of the seeds.
   3. Glutelins. These are insoluble in pure water and neutral salt solutions, soluble in dilute acids or alkalies. They are characteristic of the cereals. Combined with a prolamine, they form the gluten.
   4. Prolamines. These are soluble in 70 per cent alcohol. They are found especially in the seed of the cereals. Zein in corn, gliaden in wheat, and hordein in barley are examples.

5 Albuminoids These are insoluble in all neutral solvents, but are soluble in strong acids or alkalies which decompose them They are found in animals only Collagen, found in connective tissue, and keratin, found in epidermal tissue, such as hair, horn and hoof are examples

6 Histones These are soluble in water but insoluble in very dilute ammonia They are found only in animals The globin of hemoglobin in the blood is a histone

7 Protamines These are soluble in water, and not coagulable by heat They are also found in animals They have the smallest number of amino acids in their molecule of any class of proteins

B Conjugated proteins These are compounds of simple proteins with some other nonprotein groups. The nonprotein groups are usually acid in reaction

1 Nucleoproteins These are proteins combined with nucleic acid and are especially characteristic of the nucleus of the vegetable or animal cell

2 Glycoproteins These are proteins combined with substances containing a carbohydrate group other than nucleic acid The mucins and mucoids are the most important

3 Phosphoproteins These are proteins combined with some phosphorus containing substance Casein in milk and vitellin in egg yolk are important

4 Chromoproteins These are conjugated proteins in which the additional groups are colored The most common is hemoglobin which is a combination of globin and hematin and gives the red color to blood

5 Lecithoproteins These are proteins combined with lecithin

C Derived proteins This group is artificial but includes all those decomposition products of the simple proteins that are produced by the action of enzymes or other agencies

1 Primary protein derivatives These include proteans metaproteins and coagulated proteins They are derivatives of proteins in which the proteins have been broken up slightly

2 Secondary protein derivatives These include proteoses peptones and peptids each simpler than the preceding one They are obtained by the breaking up of the protein molecule

COMPOSITION OF PROTEINS All proteins contain carbon, hydrogen, oxygen, and nitrogen many contain sulfur, and a few contain phosphorus or iron The protein molecule is very complex, and there are very few proteins of which the exact formula is known That of hemoglobin has been given as $C_{758}H_{1203}O_{218}N_{195}S_2Fe$

STRUCTURE OF PROTEINS When simple proteins are broken down they yield amino acids This indicates that proteins are

made up of amino acids linked together. Approximately twenty-three different amino acids have been isolated. The number of amino acids contained in a protein molecule varies in different proteins. No two proteins are alike in this regard. Some proteins contain none of the more important amino acids. This fact is very important in the study of nutrition, since animals with single stomachs cannot produce these amino acids, many of which are essential for proper nutrition. However, in the ruminant, the bacteria in the paunch are able to make complete proteins from nitrogenous compounds. Such compounds cannot be used by single-stomach animals. The dairy cow is then able to digest *these bacteria and thus secure the amino acids needed, even* though not present in the feed. For this reason, it is not so necessary to feed high-quality proteins to the dairy cow as it is in the case of the pig or the chicken.

FUNCTION OF PROTEINS. The function of the protein in the animal body is to supply the animal with the living tissue necessary for the replacement of all worn-out material, and to supply the protein content of the milk. Protein can also be used as a source of energy.

Nonprotein Nitrogen-Containing Substances. Feeding stuffs contain a great variety of nitrogen-containing substances that are not proteins but have a very much less complex molecular structure. The most important of these compounds are amides, amines, amino acids and urea. Since plants build up proteins through the utilization of some of these compounds, they are found in more abundance in young, growing plants. Animals use amino acids to build up proteins within their bodies; when animals eat young plants, therefore, they obtain these compounds in a more or less predigested state. Armsby [*] at first thought that these compounds could not be used by animals, so he originated the term "digestible true protein," by which he meant simply the digestible crude protein minus these nonprotein nitrogen-containing substances. It is now agreed, however, that nonprotein nitrogen can be used as food in the body of the dairy cow, with the aid of the bacteria and other organisms in the paunch which build these compounds up into protein in their own system and later the cow gets the benefit of this change.

[*] *U.S D A Bur. Animal Ind. Bul* 139.

Carbohydrates The carbohydrates of plants are the most important parts of the feeding stuffs They are found only in small amounts in animals but are especially characteristic of plants, in which they form about 75 per cent of the entire dry matter and are the chief source of energy for the animal body The carbohydrates of feeding stuffs are divided into crude fiber and nitrogen free extract

Crude fiber is the more insoluble, woody portion of the carbohydrates and consists of the hemicelluloses, celluloses, and pentosans These compounds usually contain a considerable amount of lignin Lignin is the more fibrous part of a plant and is even less digestible than the cellulose It is deposited around the cellulose fibers The bacteria in the paunch reconvert the cellulose quite easily to soluble compounds for their own use and for absorption However as the plant matures and the amount of lignin covering the cellulose increases, the bacteria have increasing difficulty in digesting the cellulose, since even the bacteria are unable to digest the lignin Thus every plant stem which has become mature and encrusted with lignin is less digestible, because the bacteria have greater difficulty in digesting the cellulose into simple compounds The crude fiber cannot be used to any great extent by animals with single stomachs but can be used as will be seen later, by the ruminant Crude fiber is determined by the chemist by boiling a sample of feed in weak acid and alkali and washing out the dissolved matter It is less digestible than the other nutrients of feeding stuffs and becomes less digestible as the plant matures

The nitrogen free extract is the more soluble portion of the carbohydrates It includes the sugars the starches, and the more soluble portions of the cellulose and pentosans It also includes the organic acids such as lactic, butyric and acetic It is determined by the chemist by difference and not by direct analysis The total dry matter minus the sum of the protein, ash, fat, and fiber gives the nitrogen free extract It has a high nutritive value

Composition of Carbohydrates The term carbohydrates means simply a compound composed of carbon, and hydrogen and oxygen in the proportion in which they exist in water The more important carbohydrates in nutrition are as follows

1. Monosaccharides, or simple sugars, $C_6H_{12}O_6$. In this group glucose, levulose, and galactose are the most important. Of these, glucose is the most common. It is not commonly found in the feed, but is the sugar of the body. Most carbohydrates, before they can be utilized by the body, are converted into glucose.
2. Disaccharides, or compound sugars, $C_{12}H_{22}O_{11}$. In this group, sucrose, maltose, and lactose are the most important. They are compounds of two molecules of the simple sugars, with the elimination of one molecule of water, $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$. Sucrose, also known as cane sugar, is the best known. It is the sugar of the beet and the cane, and is made from one molecule of glucose and one of levulose. Maltose, or malt sugar, is formed by the union of two molecules of glucose; lactose, the sugar of milk, is formed by the union of one molecule of glucose with one of galactose.
3. Polysaccharides $(C_6H_{10}O_5)_x$. Several compounds belong to this group, but the most important in nutrition are the starches, glycogen, and cellulose. They are compounds of many molecules of the simple sugars. The starches are the reserve carbohydrates of the plant and are very abundant, especially in seeds, fruits, and roots. Glycogen is the storage carbohydrate of the body and is not found in plants. Cellulose is even more complex than the starches and goes to make up the woody parts of the plant. As plants mature, the cellulose combines with other substances, especially lignin, and forms compounds even more insoluble.
4. Pentosans $(C_5H_8O_4)_x$. The pentosans are found in large amounts in animal feeds. They are the result of the union of a large number of molecules of pentose, $C_5H_{10}O$,, in the same way as starch is formed from the union of many molecules of glucose. They are found in the largest amounts in the woody portion of plants. They are very abundant in many of the common feeds. The straws contain from 23 to 30 per cent, corn contains 5.9 per cent, and cottonseed meal, 7 per cent

Properties of Carbohydrates. Carbohydrates have three important properties in nutrition. They are unstable, easily oxidized, and easily reduced. All carbohydrates are unstable in the presence of living protoplasm and can be easily broken down or changed into other sugars. They are readily oxidized, heat being given off during the oxidation (exothermic). In this manner they can be used as fuel in the body. They are also easily reduced and form products which can be readily turned into fat. In this way, they can store up heat (endothermic).

Function of Carbohydrates. The carbohydrates are the energy givers of the body. They are not stored in the body in

large amounts as carbohydrates, but can be changed into fat, the form in which energy is largely stored

Fats Fats are not as important in nutrition as either carbohydrates or proteins, but they do play some part and are made and stored in large quantities by farm animals It appears that a limited amount of fat in the feed of the dairy cow is essential The chemist determines the fat of feeding stuff by treating a sample of feed with ether, which dissolves the fat and related substances This is called ether extract by the chemist, since it really contains other substances besides the fats

STRUCTURE OF FATS Fats are formed by a union of compounds, known as fatty acids, and glycerol They contain the same elements as carbohydrates, but their proportion of oxygen is much less, and that of carbon and hydrogen much greater The principal saturated acids contained in the animal fats are palmitic acid, $C_{15}H_{31}COOH$, stearic acid, $C_{17}H_{35}COOH$, and arachidic acid, $C_{19}H_{39}COOH$ Others occur in small amounts In butterfat a large number of the fats in the lower series are present, such as butyric, C_3H_7COOH

The unsaturated acids differ from the saturated acids in that they contain 2 or more carbon atoms united by 2 bonds As a result, the unsaturated acids contain less hydrogen than the saturated The most important one in animal fat is oleic acid, $C_{17}H_{33}COOH$ Linolenic acid, $C_{17}H_{29}COOH$, found in linseed oil, and linolic acid, $C_{17}H_{31}COOH$, found in cottonseed oil, are also unsaturated

CHARACTERISTIC PROPERTIES Fat can be changed into fatty acids and glycerol, and vice versa The one is a process of hydrolysis, the other, of condensation This is a very important reaction in nutrition It is isothermic and so does not require energy

$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + 3C_3H_7COOH \leftrightarrow \begin{array}{l} CH_2OOCC_3H_7 \\ | \\ CHOOCC_3H_7 \\ | \\ CH_2OOCC_3H_7 \end{array} + 3H_2O$$

Fats are soluble in ether, in oils, in oily materials, and in oleic acid They also emulsify very easily These properties are of great importance in nutrition.

FUNCTIONS OF FATS. The fats are used in the animal body as a source of fuel. They are a concentrated form of fuel, containing much more energy per unit than any of the other nutrients. Since this is true, they are well adapted for the storage of reserve energy in the body, for which function they are used. They also have, to a limited degree, certain structural functions.

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3

The Work of Digestion

The animal body secures all the nutrients for its growth from solutions of the food, much in the same way that plants secure all the nutrients for their growth from water solutions in the soil The process of preparing the food ingredients for passage into the blood stream is known as digestion It is a process that requires, first, that the food be broken down by mechanical means into very small particles, and second, that the complex molecules be broken down into simple ones so that the soluble portions can be separated from the insoluble, and the latter eliminated from the body In this process the carbohydrates are broken down into monosaccharides or organic acids, the fats into fatty acids and glycerol, and the proteins into amino acids In every step a larger, more complex molecule is broken down into a smaller, simpler one This change is brought about largely by the digestive enzymes Many other reactions in the body are dependent on enzyme action.

ENZYMES

Enzymes are organic compounds of unknown chemical structure that have the power to change or break down other organic compounds without themselves being changed or broken down Enzymes do not in themselves cause any chemical action but are merely agents which control the rate at which chemical reactions take place The most important reaction that they control is hydrolysis however, some enzymes control oxidation and others control reduction

Enzymes are sensitive to heat and can be destroyed if heated above a certain temperature Some work best in an acid medium,

others act only in an alkaline medium. Each enzyme of digestion is capable of acting only upon one kind of material; in other words, there is a specific enzyme for proteins, a specific enzyme for carbohydrates, and a specific one for fats. There are four groups of digestive enzymes: namely, the amylases, which act on starch; the invertases, which act on the disaccharides, the proteases, which act on the proteins; and the lipases, which act on fats. These are secreted in fluids by numerous secreting glands that are essential parts of the organs of digestion.

HORMONES

It has been found also that many of the body processes are controlled and regulated by substances called hormones or internal secretions, which are secreted by the endocrine glands, also called the ductless glands. These secretions are discharged directly into the blood stream or into the lypmh, from which they enter the blood stream indirectly and not through a duct like some of the digestive juices. They act as chemical messengers to various parts of the body. These hormones perform important functions in growth, digestion, metabolism, milk secretion, the "let down" of milk, and the development of sex, as will be seen in later chapters.

The more important glands of internal secretions are the thyroid gland, the parathyroid gland, the pituitary body, the adrenal glands, the pancreas, and the sex glands.

THE ALIMENTARY CANAL

The alimentary canal of the ruminants, which include the dairy animals, is much more complex than that of other animals. It includes the mouth, the gullet, the four compartments of the stomach, the small intestine, and the large intestine. These together form a long, winding canal approximately 180 feet long in the average dairy animal. The dairy animal has four compartments of the stomach: (1) the rumen, or paunch, (2) the reticulum, or honeycomb; (3) the omasum, or manyplies; and (4) the abomasum, or true stomach.

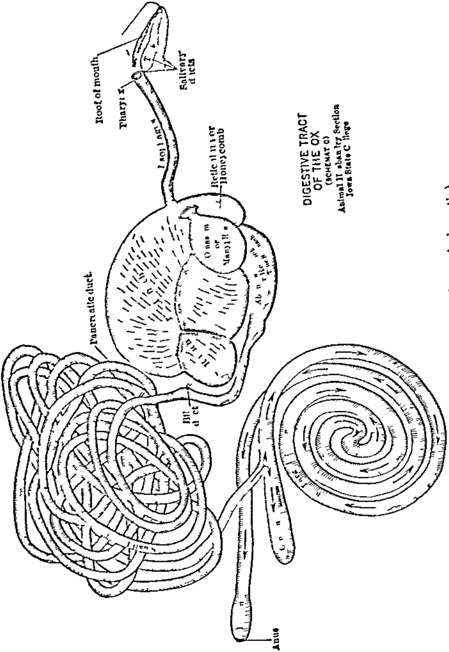

Fig 3 The digestive tract of the ox (schematic)

The first three of these may be considered as an enlargement of the gullet and should not be considered a true stomach, although they are of great importance in the digestion of coarse feeds.

Digestion in the Mouth

The mouth is the organ of prehension, mastication, insalivation, and rumination. The initial process of food gathering is called prehension, which is the seizing and conveying of the food to the mouth. The strong, mobile, rough tongue is protruded from the mouth and gathers in the feed. In case of pasture, it is drawn between the lower incisor teeth and the dental pad above and then is cut off. In pasturing, the width of the jaw, about 2½ inches, limits the width of the swath. The position of the teeth in relation to the dental pad makes it impossible for the cow to graze closer than about 2½ inches from the ground.* The head of the cow moves from side to side as she moves forward, the neck being flexed within an arc of 90 degrees. Cattle have been observed to graze continuously for as long as 40 minutes without raising their heads, although such a long time is unusual.

The second process that takes place in the mouth is mastication, which is simply the chewing of the feed preliminary to swallowing. This occurs between the molar teeth in the back part of the mouth. In this process, several objectives are accomplished. The coarse roughage is broken down into smaller particles, some of the whole grains are crushed, and the feed is mixed with saliva, a process known as insalivation. The process of mastication excites the three salivary glands, causing them to secrete a large amount of saliva, which readily mixes with the food. The amount of saliva secreted in a day's time is enormous. Colin † estimated that a cow secretes as much as 112 pounds of saliva in one day. This amount is increased if the food is unusually dry. It is alkaline in reaction with a pH above 8, due to its content of sodium bicarbonate. Many of the feeds, such as corn silage, is quite acid and it has been suggested that the ingestion of such acid feeds cause an increase in the flow of saliva

* *Guernsey Breeders J.* (June, 1948)

† *A Manual of Veterinary Physiology*, Smith.

so that the rumen content will be maintained at the proper pH which has been found to range from 6 5 to 7.5

The saliva of some animals contains the enzyme ptyalin, which converts starch to sugar In dairy animals, however, this enzyme either is entirely absent or is present in a very small amount This is an advantage, otherwise the sugars formed from the starch might be further broken down in the paunch and wasted The use of the saliva in dairy animals, therefore, is to assist mastication and swallowing, to stimulate the nerves of taste, and to assist rumination Thus no final digestion takes place in the mouth The food is merely prepared there for the later action of the enzymes in the digestive tract.

In the process of mastication and insalivation, a mass of feed, called a bolus gradually forms in the rear of the mouth At intervals, this bolus is swallowed, passing down the esophagus into the rumen It has been noted that when a cow ate whole corn one and one third boluses per minute were formed, whereas with whole oats two and one third boluses were formed per minute, and with ground feed three and one-quarter boluses were formed per minute

The fourth process that takes place in the mouth is rumination After the feed has been stored in the rumen and the cow has completed her feeding she will usually lie down and begin to chew her cud As already indicated the coarse roughage was not well chewed before swallowing This coarse material is now forced back to the mouth by the contraction of the muscles in the rumen and reticulum This action is known as regurgitation

Colin states that the bolus or "cud" weighs from 3 to 4 ounces and requires about 3 seconds to ascend and 1½ seconds to descend after complete mastication The chewing of the "cud" occupies about 50 seconds but continues until all coarse particles have been thoroughly rechewed Rumination is, therefore, a slow process and occupies the time of a cow for about 8 hours out of the 24 If an animal is alarmed or disturbed she immediately ceases to ruminate One of the very first signs of ill health is the suspension of rumination

After the food has been thoroughly masticated and mixed with saliva the act of deglutition or swallowing takes place This is brought about by the action of the muscles of the throat and

tongue, which force the food into the esophagus, or gullet, the tubelike passage extending to the stomach. The gullet of the cow is easily stretched, with the indirect result that animals are sometimes choked. Food passing into the gullet without proper mastication, such as an apple swallowed in large pieces, is likely to cause choking.

Digestion in the Stomach

The Rumen. As has been pointed out, the food passes from the mouth down the esophagus into a very important stomach called the rumen or paunch. This stomach has a very large capacity, having a breaking point of about 50 gallons. It will hold as much as 300 pounds of material. The rumen is divided into four sacs, by constrictions in the wall produced by large muscular bands. The interior of the organ is lined with a well-developed muscular membrane, covered with many pointed papillae.

The rumen has several functions. The first one is to act as a storage place. It holds the feed which the cow gathers during her grazing or eating period, and later, when she has finished feeding, she lies down and regurgitates the larger particles back to the mouth so that a more complete job of grinding can take place.

The rumen also acts as a means of breaking down the coarser pieces of food to finer pieces so that the digestive juices can have a large surface to act upon. It does this in several ways. In the *first place, liquid fills the lower half of the rumen, and by means* of a churning motion, caused by the muscular bands, the feed is driven down and thoroughly soaked in this warm liquid. The material also comes in contact with the rough pointed papillae that line the stomach. The coarse particles that are not thus broken down are returned to the mouth for further mastication. Thus by churning, soaking, and rechewing, the particles are reduced greatly in size.

The third function of the rumen is to provide a place for fermentation. As already indicated, the saliva of the dairy cow does not contain digestive juices nor is there any secreted into the rumen, yet important changes take place in the feed during the period of about 12 hours during which it remains in the rumen.

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These changes take place as a result of the action of bacteria and yeasts, which are plants, and one celled animals called Protozoa, all of which grow in great numbers in the rumen content The temperature the food, and the moist condition provide ideal conditions for their growth and multiplication These organisms in the paunch have three functions

(a) HELP DIGEST THE CRUDE FIBER Enzymes secreted by these organisms cause the softening and disintegration of the particles of roughage and bring about the breakdown of the starches and cellulose This action on the cellulose, the crude fiber of the feed is of *the greatest importance, since only the organisms* of the rumen, or enzymes secreted by them have the capacity to cause this cellulose to be digested and broken down into simple sugars and organic acids, the final aim in digestion However, even these enzymes are unable to break down the material when it is too mature and mixed with lignin

(b) BUILD UP COMPLETE PROTEINS The bacteria and yeasts are plants *and, as such have the capacity of building up proteins* from nonprotein nitrogen containing substances into their own body As these organisms die, they can in turn be digested by the cow and used in her body For this reason, it is not necessary to provide the same quality of protein as for animals with single stomachs Compounds such as urea have been fed successfully to dairy cows and probably will be fed extensively in the future when its price is sufficiently lower than the price of protein from plant sources

(c) MANUFACTURE THE B COMPLEX VITAMINS A *third function* of the rumen organisms is the production of a considerable amount of the various B-complex vitamins This includes such vitamins as thiamine, riboflavin niacin pantothenic acid pyridoxine, biotin B_{12}, and others Since the organisms can manufacture them the dairy cow need not be fed these vitamins that are so essential to single stomach animals The dairy cow then is able in her digestive system to absorb these vitamins from the bacteria into her blood and they then become available for the functions of the body or for inclusion into the milk *It is of* interest to note that not all the vitamins present are absorbed from the digestive tract since *some of them pass out in the feces* It has been found that dried cow s feces is rich in these vitamins

and makes an excellent substitute for alfalfa meal in the rations of chicks, pigs and laying hens.

In the fermentation process, several kinds of gases are produced. Carbon dioxide (CO_2) and methane (CH_4) are produced in greatest abundance, but hydrogen (H), hydrogen sulfide (H_2S), and carbon monoxide (CO) may be produced in smaller amounts. Normally, these gases are passed off by the reflex action of belching. Sometimes, however, the cow is unable to get rid of this gas, and bloating results. The cause and remedy of bloating will be discussed later.

The Reticulum, or Honeycomb. The reticulum, or honeycomb, is much smaller than the rumen, and is really the forepart of the rumen. In the dairy cow it has a breaking point of about 13 quarts. Its interior is lined like a honeycomb, hence the popular name. It is connected with the rumen and the esophagus by means of the esophageal groove. In this sac, stones, nails, and other foreign objects may frequently be found, driven there by the churning movement of the rumen. Sometimes nails or wire penetrate the heart from the reticulum, causing the death of the animal.

The contents of the reticulum are fluid and alkaline. There is no secretion from the walls of this stomach, and as a result, it has no true digestive power. Its function has not been fully demonstrated, but it seems to assist in passing the bolus up the esophagus and in regulating the passage of the food from the rumen to the omasum and from the rumen to the esophagus.

The Omasum, or Manyplies. After the food has been thoroughly masticated and broken down it goes directly to the omasum. This is a peculiarly shaped organ with a breaking point of about 20 quarts. The omasum, like the reticulum and rumen, possesses no secretive powers but consists of powerful muscular leaves that squeeze the water out of the food that it receives. Some of this water is absorbed by the organ, but most of it passes directly to the abomasum, or true stomach. The solid portion remains in the omasum to be further acted upon by the leaves. These leaves are covered with papillae which become shorter, thicker, and stiffer as the food advances. The movement of the leaves is not simultaneous, but successive, in such a way that the rasping of the food is continuous, so that the food is

ground finer and finer until it enters the abomasum When illness occurs, rumination ceases, thus cutting off the chief supply of fluid to the omasum The content then becomes dry and sometimes cakes, resulting in a condition in which it is practically impossible to pass anything through the animal From the omasum the food passes directly into the abomasum

The Abomasum, or True Stomach This organ, which has a breaking point capacity of about 20 quarts, is the true digestive stomach of the cow The walls of this stomach secrete the gastric juices which contain less than 0.5 per cent of hydrochloric acid, and the two enzymes, pepsin and rennin Pepsin can act only in an acid medium hence it is the function of the hydrochloric acid to change the alkaline condition, which the food has maintained up to this point, to an acid one Pepsin acts on the proteins and breaks them down into simpler compounds, mainly peptones and proteoses, but does not break them down into *amino acids*

Rennin is an enzyme that curdles milk, and is therefore very important in young calves that are fed milk If it were not for the action of the rennin, the milk might pass through the digestive tract without being acted on by the other digestive enzymes

Digestion in the stomach is sometimes spoken of as a process of chymification, since the pulpy mass of semiliquid food that is ready to pass from the true stomach to the intestines is spoken of as chyme, and in the intestines it is called chyle The opening of the stomach into the intestines is controlled by a sphincter muscle, which, in turn is controlled by the reaction of the chyme When the chyme within the stomach becomes acid to a certain degree, this sphincter muscle relaxes and allows some of the chyme to pass through into the intestines Mechanical stimulation may also have some effect in keeping this muscle rigid

Digestion in the Intestines

The intestines are composed of two well-defined parts, the small and the large intestine The small intestine is a long, folded tube into which the stomach empties Its length in the cow is about 135 feet, and it has a capacity of about 40 quarts The walls of the intestines are covered with very small, fingerlike pro-

jections called villi, which have a lashing movement, thus helping to mix the content of the intestines. The chyle is carried along in the intestines by a peristaltic movement. This is a wave of constriction followed by a wave of relaxation. The chyle moves very slowly, and the digestive juices have plenty of time to do their work. The upper part of the intestinal tract is specialized for secretion, and the lower part for absorption. In the intestines, the chyle comes into contact with three digestive juices: the pancreatic juice, the bile, and the intestinal juice.

The Pancreatic Juice. The pancreatic juice is a clear, watery fluid with an alkaline reaction. It is secreted by the pancreas, or sweetbread, which is a slender gland lying just below the stomach. Careful experiments have shown that the pancreatic juice flows only when chyme is coming from the stomach. This chyme is acid in reaction. The acid, acting on the mucous membrane of the lining of the intestines causes it to form secretin, a hormone which is absorbed into the blood and carried to the pancreas, which it stimulates to secrete the pancreatic juice just when it is needed. In this way the organs of digestion are made to work in harmony. The pancreatic juice contains three enzymes: trypsin, amylase, and lipase. Trypsin is a protease and, like pepsin, acts on the proteins, converting them into proteoses and peptones and breaking them up to a certain extent into amino acids, in which form the protein can be taken up by the animal body. Trypsin will not work on the protein until it is made active by coming in contact with the enzyme enterokinase, which is secreted by the intestinal walls. Amylase converts starches into maltose. In a ruminant, such as the dairy cow, it is undoubtedly used more largely than in a nonruminant, where ptyalin has a greater effect. Lipase separates the fat into fatty acids and glycerol, thus enabling them to pass through the walls of the intestines. Some of the fatty acids unite with the alkalies in the bile and form soaps, a form in which they are soluble.

The Bile. The bile is the thin, yellowish-brown, or greenish liquid secreted by the liver. It is alkaline in reaction and changes the reaction of the chyme as it comes from the stomach from an acid to an alkaline or neutral one. Bile is stored in the gall bladder and flows only when required. It is stimulated by a hormone in the same manner as the pancreatic juice. Bile does not

contain any digestive enzymes, but it does greatly aid digestion It is useful in emulsifying the fats, breaking them up into very small globules, and thereby greatly increasing the surface area so that the lipase can work on them more easily It furnishes salts that may combine with fatty acids, thus forming soaps, in which form fat can be taken up by the body It also helps dissolve the soaps and fatty acids If bile is excluded, the digestion of fat is reduced and this in turn retards the digestion of carbohydrates and proteins One of the acids that bile contains taurocholic, accelerates the peristaltic movement of the intestines Colin states that the cow secretes approximately 5 7 pounds of bile in a day

The Intestinal Juice The mucous membrane of the intestines is lined with glands that secrete the intestinal juice, also known as the succus entericus This fluid contains several enzymes the most important of which are erepsin a proteolytic enzyme and the invertases, namely, sucrase, maltase and lactase It also contains enterokinase the principle that activates trypsin

Erepsin acts on the proteoses and the peptones which have been broken down from the proteins by the pepsin and trypsin, and further breaks them down to simple amino acids It cannot act on protein that has not already been broken down to the proteoses and peptones

Sucrase maltase and lactase convert the cane malt, and milk sugar into the simple sugars Sucrose is broken down into one molecule of glucose and one molecule of levulose maltose, into two molecules of glucose, and lactose, into one molecule of glucose and one of galactose These enzymes do not act upon the starch

The Large Intestine When the content of the small intestine reaches the large intestine it still contains undigested food The food remains in the large intestine a relatively long time, thus permitting the digestive processes started in the small intestine to continue and also permitting complete adsorption of all digested food In the large intestine the food undergoes a great deal of bacterial action Putrefaction takes place causing the offensive odor of the feces and often setting free large quantities of poisonous products No digestive fluid is secreted in the large intestine, but many katabolic products are there returned to the

digestive tract. Often the food remains in the large intestine for some time and becomes more solid, much of the water being absorbed. It is finally passed out through the anus as feces. The feces consist of the undigested residue of the feed, the remains of the digestive secretions, waste material resulting from wear and tear on the digestive tract, certain excretory products, and the bacterial flora.

Chemistry of Digestion

Water requires no digestive process. It is simply absorbed by the capillaries of the villi of the entire digestive tract. The *mineral matter* also passes into the blood stream probably without being acted upon by digestive enzymes. Some of the minerals may be taken up in organic combinations, but most of them are brought into solution, to a greater or lesser extent, by the hydrochloric acid of the gastric juice or by other agencies.

The proteins are first acted upon by the pepsin of the gastric juice in the abomasum. They are there broken down to proteoses and peptones. The trypsin of the pancreatic juice also breaks down proteins and converts them chiefly into proteoses and peptones, although it may convert some of them into amino acids. The erepsin of the succus entericus works on the proteoses and peptones and converts them into amino acids, which are the final products of protein digestion.

Of the carbohydrates, the starch is broken down to maltose by the enzyme amylase. The compound sugars are then converted into the simple sugars by the invertase enzymes, maltase, lactase, and sucrase—maltose forming two molecules of glucose; sucrose, one molecule of glucose and one of levulose; and lactose, one molecule each of glucose and galactose. The cellulose and pentosans, however, are not attacked by the enzymes secreted by the walls of the digestive tract. The digestion of the cellulose and pentosans is a process of fermentation, brought about by enzymes secreted by bacteria which accompany the food. This occurs in the paunch. The products of fermentation are gases, such as methane and carbon dioxide, which cannot be used as food, and sugars and organic acids, such as butyric, acetic, and lactic, which may be taken up and used as food.

The fats are not acted upon to any extent until they reach the small intestine. Here they are hydrolyzed into glycerol and fatty acids by the enzyme lipase, which is secreted in the pancreatic juice. The bile causes emulsification to take place. If any free alkali is in the digestive tract it may unite with the fatty acids, converting them into soap, but not all the fatty acids are converted into soap.

The process of digestion is complete when the proteins have been converted into amino acids, the starches into simple sugars, and fats into glycerol and fatty acids.

Digestibility of Foodstuffs

The word "digestion" is used to include all the processes necessary for the conversion of food into the soluble forms in which it is assimilable. However, not all the food can be converted into soluble forms so that it can be absorbed. To determine what portions of a food may be absorbed, digestion trials are run. For this purpose it is necessary to analyze the foods consumed and the feces excreted, the difference between what is fed and what is excreted is said to be the digestible food. The coefficient of digestibility is the percentage of food that is digested. The sheep and the steer have been used more often than any other animals in digestion trials for the determination of the coefficient of digestibility. The dairy cow has not been used so often because it is difficult to harness her in such a way that the liquid portion of the excreta is kept separate from the solid portion. When dairy cows are used it is essential that they be watched constantly in order to make such separation. For the proper conduct of a digestion trial, samples are taken for from 6 to 10 days after a preliminary period of 2 weeks. It is necessary that several days' collection of excreta be taken in order that a satisfactory average may be secured. Aliquot portions of the daily excreta are saved and composited for the final sample.

To illustrate how the digestibility of a feed is determined, let us assume that during a digestion experiment a cow consumed 3000 grams of timothy hay, analyzing 7 per cent protein, 34 per cent fiber, 50 per cent nitrogen free extract, and 1.8 per cent ether extract. During the trial the cow excreted 1300 grams of feces,

which analyzed 10.0 per cent crude protein, 35 per cent crude fiber, 46 per cent nitrogen-free extract, and 2 per cent ether extract.

From these figures it can be calculated that the amount of the feed digested and the coefficient of digestibility of the dry matter of timothy is as shown in Table VI.

TABLE VI

AMOUNT OF NUTRIENTS FED, EXCRETED, AND DIGESTED, AND COEFFICIENT OF DIGESTIBILITY OF DRY MATTER IN TIMOTHY HAY

	Crude Protein, grams	Crude Fiber, grams	Nitrogen-Free Extract, grams	Ether Extract, grams
Timothy hay	210	1020	1500	54
Feces	130	455	598	26
Digested	80	565	902	28
Coefficient of digestibility	38.1	55.4	60.1	51.8

It is assumed that the feces contains only undigested food. This is not strictly true, since many metabolic substances are added from the blood and from the excretions that enter the digestive tract, and there is no method of determining these metabolic products; hence, that which *is really apparent digestibility* is called digestibility. Since some of the minerals, especially calcium, phosphorus, iron, and part of magnesium are excreted mainly through the intestines, this method cannot be used to determine their digestibility or absorption.

Total Digestible Nutrients. To find the percentage of digestible nutrients in a feeding stuff, the percentage of each nutrient is multiplied by the coefficient of digestibility for that nutrient. As an example, the analysis of timothy hay and the coefficients given in Table VI will be used. The results are given in Table VII.

The total digestible nutrients of any feeding stuff is determined by taking the sum of the digestible crude protein, the digestible carbohydrates (crude fiber and nitrogen-free extract),

TABLE VII

THE COMPOSITION, COEFFICIENT OF DIGESTIBILITY AND DIGESTIBLE NUTRIENTS OF THE DRY MATTER OF TIMOTHY HAY

	Crude Protein, per cent	Crude Fiber, per cent	Nitrogen-Free Extract, per cent	Ether Extract, per cent
Analysis of timothy	7.0	34	50	1.8
Coefficient of digestibility	38.1	55.4	60.1	51.8
Digestible nutrients	2.67	18.84	30.05	0.93

and $2\frac{1}{4}$ times the digestible fat (ether extract). In the foregoing example it would be

$$2.67 + 18.84 + 30.05 + 2\tfrac{1}{4}(0.93) = 53.65.$$

There would therefore be 53.65 pounds of total digestible nutrients in 100 pounds of the sample of timothy hay.

The total digestible nutrients (T.D.N.) are simply the nutrients of the feeding stuff converted into carbohydrate equivalents. On an average, fat contains about $2\frac{1}{4}$ times as much energy as carbohydrates, and protein contains about the same amount as carbohydrates.

Since protein has certain functions that cannot be performed by the other nutrients, the percentage of digestible protein is given in the tables, along with that of the total digestible nutrients, although it should be borne in mind that the digestible protein is included in the total digestible nutrients.

Factors Influencing Digestibility. Several factors influence digestibility. Animals of different species vary widely in the percentage of food digested, but animals of the same species are nearly the same in this respect. There is very little difference between the various breeds of dairy cows. The main differences are individual and are due to faulty teeth, diseased digestive organs, intestinal worms, etc., but these differences rarely exceed 3 or 4 per cent. In the young calf the first three parts of the stomach are not well developed, and until the calf is old enough to eat roughage it cannot ruminate and properly develop the first three compartments. After the stomach is fully developed, the

age of the animal seems to have but little influence on the percentage of food digested Heavy feeding seems to decrease the digestibility of the feed, probably because of the greater bulk, the relatively rapid passage through the digestive tract, and the consequent less time for the bacterial fermentation Roughages, especially when overripe are as a rule less digestible than concentrates, because large amounts of crude fiber and lignin in such feeds tend to protect them from the action of the digestive juices It has also been observed that when cattle are fed very poor rations consisting of straw, cornstalks, or other feeds of like nature, the bacteria flora of the paunch becomes very low, or in other words these bacteria, yeasts, and Protozoa must be fed suitable nutrients if they are to be helpful in digesting the feed Palatability may have some effect on digestibility, since it has been shown that palatability influences the secretion of the digestive juices Feeders practice cooking, soaking, grinding, and the use of condiments, with the idea of increasing digestibility Grinding does increase digestibility, especially of hard seeds, which otherwise would go through the digestive tract unbroken Grain should, therefore, be ground when fed to dairy cows The cutting of roughage or the soaking of feeds apparently does not increase digestibility

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4

The Use of Food in the Body

ABSORPTION

The food within the intestines is spread out in thin layers over the intestinal surface. The surface is increased many times by the fingerlike projections, called villi (singular, villus), that line the walls of the intestines. Each villus is supplied with an artery, a vein, a capillary, and a lacteal. The mucus of the villi is very thin. The villi are able to expand and contract and thus take up the material from the intestines like a sponge. Just how the food is taken up by the body is not fully known. The laws of diffusion and osmosis explain to a large extent the theory of absorption, yet it is believed that living protoplasm is essential to this process.

The food can enter the blood stream in either of two ways: by the portal vein and the liver, or by the lacteals into the lymphatic circulation which empties into the blood from the thoracic duct.

The amino acids resulting from the breaking down of the proteins pass through the cell wall unchanged and enter the blood stream by the portal vein. The simple sugars and organic acids also enter the blood stream by the portal vein. The fatty acids and glycerol are changed back to glycerides as soon as they enter the body. These glycerides then go into the lymph system in a very fine state of emulsion and later enter the blood stream by way of the thoracic duct. After a meal rich in fat, the chyle in the lymph system, flowing away from the digestive system, is white in color. Although a large part of the absorption takes place in the small intestine, some of the nutrients also enter from the large intestine.

CIRCULATION

The Blood In the process of digestion the food is converted into simple compounds which must be carried to the parts of the body where they are needed This is done by means of the blood circulation The central organ of the circulation is the heart which is divided into four quarters The nutrient rich blood coming to the heart enters the right auricle and from there is

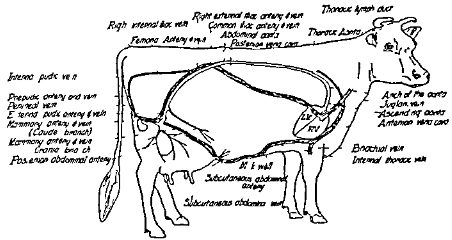

FIG 4 Circulatory system of the cow (schematic) A single large artery supplies blood to both the rear and front quarter of the udder Three distinct veins carry the blood back to the heart (*Turner*)

forced into the right ventricle This contracts and forces the blood out through the lungs where it is relieved of its carbon dioxide and takes on a supply of oxygen The blood then returns to the left auricle whence it is forced into the left ventricle which by contracting powerfully drives the blood through the aorta and the subdividing arteries to all parts of the body The arteries divide repeatedly into smaller branches and finally carry the blood to the capillaries It is through the capillaries that the cells receive their supply of oxygen and food and unload their waste products From this point the blood returns to the heart through the veins

The blood has many important functions among which are the carrying of digested food from the digestive tract to the tissues

the carrying of oxygen from the lungs to the tissues, and the carrying away of all waste products of the cells to the proper place of disposal. The blood serves to keep the heat of the body evenly distributed, and it transfers water from one part of the system to another. All internal secretions are carried by the blood.

The blood is a red, opaque, rather viscous fluid. It is alkaline in reaction. The shade of red depends upon whether the source of the blood is an artery or a vein. According to Sussdorf,* blood forms about 7.7 per cent of the weight of a living cow's body. It is composed of serum, red corpuscles, white corpuscles, blood platelets, and fibrin. The number of red corpuscles in the blood is enormous, being estimated at 4 to 6 million per cubic millimeter. They contain as a characteristic ingredient the conjugated protein hemoglobin. The hemoglobin carries the oxygen from the lungs to the tissues, the blood serum carrying the food.

The Lymph. The body cells are not closely packed together but are surrounded by a colorless, transparent fluid known as lymph From it, by osmosis or in other ways, the cells receive their food, and into it they deposit their waste. The lymph in turn is separated from the blood only by the thin walls of the capillaries, through which the lymph is supplied with food and eliminates its waste. The lymph spaces unite to form the lymphatic system, which empties into the jugular vein in the lower left side of the neck.

METABOLISM

The cell, as defined by Armsby,† is the biological unit of life. The cells are the laboratories of the body, within which extensive chemical reactions take place. In them the food is either built up into body tissue or broken down to serve as a source of energy, as the case may be. The sum total of the chemical changes which the food undergoes in the body is known as *metabolism*. Those processes by which simple materials are built up into more complex ones are spoken of as *anabolism;* those by which living matter is broken down into simpler substances are spoken of as *katabolism*. Whereas digestion is characterized by hydrolyses, metab-

* *A Manual of Veterinary Physiology*, Smith

† *The Nutrition of Farm Animals*, Armsby

olism in general is characterized by oxidation, although other forms of reaction are common These reactions are thought to be brought about by intercellular enzymes which are present in every cell and are able to alter the velocity of chemical reactions and thus to keep the mechanism of the body running smoothly The final end and aim of metabolism is to supply energy for the vital activities of the body The demand for energy is the controlling factor in the activities of the cells

Ash Metabolism Very little is known concerning the metabolism of ash As previously pointed out, many of the ash ingredients are essential to the vital processes of the animal body It may be assumed that they enter the body either in solution as inorganic salts or in combination with organic substances It has been found that sulfur is taken into the body largely in organic combinations and is built up in the body as such Inorganic sulfur cannot be used by the animal Phosphorus is probably taken into the body as phosphoric acid Phosphorus along with calcium constitutes a large part of the bones, but it is also found in many other parts of the body and in organic combination The cells seem to be able to use inorganic phosphorus for building up organic compounds At least two other ash ingredients enter into organic combinations within the animal body They are the iron of the hemoglobin and the iodine of the thyroid gland Little is known concerning the metabolism of any of the other ash ingredients, but it is thought that they go into solution and are taken up and used in that manner

Protein Metabolism As previously noted, the proteins are absorbed in the form of amino acids These are carried in the blood to the parts of the body where they are needed, and there they are built up into new proteins peculiar to the tissues in which they are formed and different from the proteins from which they were derived Each individual cell seems to have the power of building up these compounds through a condensation process Here they are used in the repair and synthesis of tissue

In the katabolism of proteins two general stages are recognized The first stage is one of hydrolysis by which the proteins are broken down into amino acids in the second stage the nitrogen is split off from these acids as ammonia This process is known as

deaminization. The ammonia resulting from it is rapidly converted into urea or, in the Herbivora, largely into hippuric acid, in which form it is excreted from the body by means of the urine. The residue of the amino acid, after the removal of the ammonia, is closely related chemically to both the carbohydrates and the fats, and may, like these, be used to supply energy, or, as has been shown with some of the amino acids, may be converted into glucose. It is probable that fat can be formed from protein, but the amount of fat thus formed under normal conditions is insignificant. All these reactions are supposedly brought about by intercellular enzymes.

The nonprotein nitrogen-containing material, consisting chiefly of amides and amino acids, probably enters the body in the form of amino acids and is used as such.

Carbohydrate Metabolism. Glucose, levulose, and galactose pass through the portal vein and are carried to the liver and tissue. Here, by a process of condensation, they are changed into a polysaccharide, glycogen. The liver acts as the principal storehouse of glycogen, although some of it is stored in the tissues. As much as 10 to 15 per cent of the weight of the liver may be glycogen, and about one-half of this amount may be stored in the tissues. No glycogen is found in the blood. If more glucose is provided than the liver and muscles can take care of at once, it is eliminated through the urine. The amount of glucose in the blood is from 0.1 to 0.2 per cent, but remains remarkably constant and seems to be regulated by the supply stored in the liver and tissues. If the supply of glucose from the intestine is insufficient to maintain the normal supply in the blood, the glycogen is changed by hydrolysis into glucose, and thus the supply of glucose in the blood is kept constant. It is believed that this reaction is brought about by intercellular enzymes. A hormone (insulin) produced by the pancreas is required for the oxidation of the glucose in the body. The removal of the pancreas results in the loss of glucose through the kidneys, as in diabetes. Much of the energy used by animals to warm their bodies, to do muscular work, and to produce milk comes from the oxidation of glucose and the simple sugars. In ordinary feeding stuffs, one-half to two-thirds or even more of the oxidizable material consists of

carbohydrates, which when digested are taken up as simple sugars Also, about 60 per cent of the protein and 10 per cent of the fats are believed to be converted into glucose in the course of metabolism

According to Shaffer,* glucose may be burnt during metabolism into carbon dioxide and water, with or without an intermediate conversion into glycogen, or it may be converted into fat by reduction The path of glucose metabolism *is through a series of reactive compounds, and it is these substances resulting from molecular rearrangements that are finally oxidized, liberating energy, or are synthesized into fat and other substances* Jordon and Jenter † have demonstrated that with dairy cows much of the milk fat is produced from carbohydrates

The organic acids resulting from the fermentation of the celluloses and pentosans enter the body without change The lactic and acetic acids can be used directly for energy, and the others are probably changed into forms in which they can be used

Fat Metabolism The fatty acids and glycerol, upon entering the lymphatic circulation, are changed back to glycerides and in this state are carried as a fine emulsion through the thoracic duct, which empties into the blood stream in the neck Just how the blood carries the fat is not fully known Bloor ‡ states that the red blood corpuscles take up the fat from the plasma and transform it into lecithin and that lecithin is an intermediate step in the metabolism of fats Gage and Fish § were able to follow the very minute particles of fat emulsion, which they call chyle microns, in the blood through the entire body, by the aid of a high power dark field microscope They found that these particles appeared in the blood ½ to 1½ hours after eating and that after 6 to 8 hours they had disappeared from the blood They also found, by means of dyes, that the source of the fat in the milk of dairy cows was not the fat in the food, although it seemed to be in the goat and some other animals

The fat is stored in the adipose tissues and can be used as a

* *Physiol Rev*, 3 394

† *N Y Exp Sta Bul* 132

‡ *J Biol Chem*, 24 449

§ *Am J Anat*, 34 1

source of energy when needed. It has been shown that, when the food supply is inadequate, the stored fat is drawn upon for the support of the internal activities of the body and as a source of energy. The exact chemical changes that take place are not known, but it is probable that different lipase enzymes which are widely distributed in the body break up the fat into glycerol and fatty acids, which are then oxidized. The final products of this oxidation are carbon dioxide and water. Whether fat can be converted into glucose is not fully known. It is thought, however, that at least the glycerol part can be so converted.

PATHS OF EXCRETION

The vital activities of the body lead to the formation of products that must be removed. The most common of these are carbon dioxide, water, urea, and some mineral ingredients. An accumulation of such products tends to stop the vital activities of the cells.

Carbon dioxide is mainly given off through the lungs, but a small amount is excreted through the skin. It is carried to the lungs by the blood. Water is removed by evaporation from the lungs and from the surface of the body. According to Armsby,* a 1000-pound steer, at an ordinary temperature and on light feed, may easily excrete through the lungs and skin 8 to 10 pounds of water in 24 hours. The feces also contain a large amount of water. Water is likewise excreted in the urine, serving as a solvent for the nitrogenous products of cell activity.

The urea and other nitrogenous materials that result from protein katabolism are excreted mainly through the urine. Most of the mineral ingredients, especially sulfur, chlorine, and the alkalies, are also excreted through the urine; the intestines, however, are the usual path of excretion of calcium, phosphorus, iron, and, to some extent, magnesium.

* *The Nutrition of Farm Animals*, Armsby.

DETERMINATION OF THE USE OF FOOD IN THE BODY

The coefficient of digestibility tells the percentage of the food that is assimilated by the body, but it does not tell what use the animals make of the nutrients after they are once within the body. This has to be determined by a complete balance of nutrition, in which the entire intake is balanced against the entire outgo The intake includes air, food, and water, the outgo includes the feces, urine, gases, and heat By measuring each of these, it is possible to determine exactly how much of the gross energy of the feed the animal has been able to use for growth, fattening, work, or milk production

The Respiration Calorimeter. Several forms of respiration apparatus, permitting a very exact determination of the gaseous exchange, have been constructed, but only when a respiration calorimeter was built at the Pennsylvania Experiment Station, in 1898, was it possible to combine with a determination of the respiratory products a direct measurement of the heat given off by a domestic animal, such as the dairy cow

The respiration calorimeter at the Pennsylvania Experiment Station * consists of a stall, constructed of sheet copper, and large enough to hold a cow or steer comfortably It is completely airtight Under the rear portion of the stall there are receptacles, enclosed in a small, airtight chamber, for collecting the feces and urine which are conducted to them by means of rubber tubes This chamber is closed with an airtight door The feed and water are put into the stall through an airtight door in the front All the doors are kept tightly closed except when the animals are being fed and watered, or the excreta removed This requires only a few minutes each day Samples of the feed and excreta are taken and analyzed Exact records of their weight are also kept

The air is measured, sampled, and analyzed for water, carbon dioxide, and methane, both as it enters and as it leaves the stall The heat given off is also measured It is thus possible to determine accurately the expenditures of an animal

* *Pa Exp Sta Bul* 104

TABLE VIII

DAILY ENERGY BALANCE OF A STEER *

	Income, calories	Outgo, calories
6988 grams timothy hay	27,727	
400 grams linseed meal	1,811	
16,619 grams feces	......	14,243
4357 grams urine	......	1,210
37 grams bushings	......	88
142 grams methane	......	1,896
Heat	......	11,493
Gain in body	......	608
	29,538	29,538

* *The Nutrition of Farm Animals*, Armsby.

Table VIII shows how it is possible to compare the income and outgo of energy and get the balance of energy by means of the respiration calorimeter.

Metabolizable Energy. The animal body may be compared to a gasoline engine, requiring, first, repair material to keep it in good running order, and second, fuel or energy with which to do its work. The working part of the body is furnished by the water, protein, and ash; the energy is supplied by the carbohydrates and fats, although the protein also furnishes energy during its katabolism. The total energy furnished in the feed is the gross energy. However, not all of this is available to the body, as some is lost in the feces, some in the urine, and some in the gases that escape from the body. The metabolizable energy is that part of the gross energy which is not carried off in the urine, feces, or gases. In other words, it is the energy that is capable of transformation in the body.

Net Energy. It has been found by means of the respiration calorimeter that some energy is spent in the work of digestion. This is especially true of the Herbivora, since they consume a large amount of rough feed. The metabolizable energy minus the energy required for the work of digestion (heat increment) is known as the net energy. Armsby defines the net energy value of a feeding stuff as the energy remaining after the losses of chemical energy in the various excreta and also the energy ex-

pended in the processes incident to the consumption of the material have been deducted from its gross energy.

An example of the method of determining the net energy value of a feeding substance is given in Table IX. In the balance ex-

TABLE IX

DETERMINATION OF NET ENERGY VALUE OF TIMOTHY HAY *

	Dry Matter of Hay Eaten pounds	Metabolizable Energy calories	Heat Produced calories	Gain of Energy calories
Period 4	10.21	9544	9812	−268
Period 3	6.17	5768	8064	−2296
Difference	4.04	3776	1748	2028
Difference per pound dry matter of hay		935	433	502

* *The Nutrition of Farm Animals*, Armsby.

periments with a steer two different amounts of timothy hay, both insufficient for maintenance, were fed during successive periods.

Here the net energy of 1 pound of dry matter was 502 calories. This is the amount of energy that the animal actually has left with which it may do work, put on fat, or produce milk, as the case may be. The loss of energy due to the work of digestion is much greater with feeds high in fiber than in those low in fiber.

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5

Milk Secretion

The food that enters the body of the dairy cow is used not only for building up tissue and performing work but also for producing milk For milk production a large amount of food is necessary The blood carries the food material to the udder of the cow, where it is collected and changed into the components of milk, some of which are found nowhere else in nature Only a very small part of the nutrients in the blood is taken out each time that the blood passes through the udder It has been estimated that about 400 pounds of blood passes through the udder for each pound of milk produced If this is true it would be necessary, in a cow producing 50 pounds of milk per day, that 10 tons of blood flow through the udder daily The energy required to pump this amount of blood, which really is only a small part of the work of milk production, indicates that good dairy cows are hard working animals

STRUCTURE OF THE MATURE UDDER *

The udder of a cow is normally composed of four mammary glands two (the fore and rear quarter) in each half There may be one or more supernumerary, or extra, teats, with small glands, but these glands usually do not develop The right and left halves of the udder are separated by a distinct septum, called the median suspensory ligament. As viewed from the side, the udder should have a rounded, saccular appearance with attachments extending high behind and carried well forward

Upon dissection each half of the udder is found to be enclosed in a strong fibrous sac On the inner side where the halves join,

* *Mo Exp Sta Buls* 344 and 346

the fibers intermingle and extend upward to the abdomen, where an attachment is made This structure is known as the median suspensory ligament On each side of the udder are found the

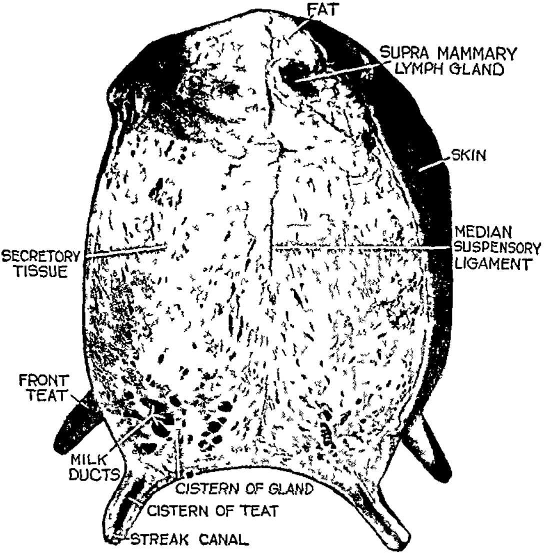


FIG 5 Cross section of the rear quarter of a cow s udder (*Turner*)

lateral suspensory ligaments which, together with the skin, serve as the chief support of the udder Any weakness in the central support will cause the teats to stick out, or 'strut,' as it is some times called, and a weakness in the lateral suspensory ligament causes the udder to break down

The quarters in each half of the udder are not as distinctly separated as the halves However, they are divided by a very

thin connective septum, irregular in outline, which permits no mingling of the secretion of the two glands

The entrance from the outside to the udder is through a canal (streak canal) which is ¼ to ⅜ inch in length This canal is kept closed by a circular sphincter muscle near its outer end This muscle serves to keep the milk in the udder, between milkings, and also to keep bacteria and other foreign material out of the udder If this canal is small, or if the sphincter muscle is unusually tight, the cow is a "hard milker" If this muscle is not held tight, the udder will leak milk and the cow will be a "leaker"

The streak canal enters the teat cistern, which is the cavity of the teat, into which the milk drains naturally, and from which milk is expressed, during the process of milking, by shutting off the upper part of the teat cistern and applying pressure below which forces the milk out through the streak canal The teat cistern opens into the gland cistern These two cisterns are separated partially by a circular fold which extends into the cavity, making a very definite separation Ordinarily, this fold does not interfere with the draining of the milk into the teat cistern but sometimes it becomes so thick that the milk drains very slowly

The gland cistern acts as a reservoir for the milk. It is an opening of considerable size, varying somewhat in size and shape with different individuals and even with the different quarters of the same individual An average capacity would probably be about one pint, although it may vary from ¼ pint to as much as 1½ to 2 pints

A number of large ducts lead through the upper and lateral walls of the cistern The number of ducts varies from 12 to as many as 50 in each quarter These ducts branch very irregularly. In some cows the duct branches into two ducts of equal size, in others, smaller branches are given off from the main duct These ducts continue to branch until they become quite small, and finally end in an enlargement that is called an alveolus, or acinus

The alveolus is a very small structure almost spherical in shape and lined with a single layer of epithelial cells These cells are connected on the base side to the blood capillaries, the lymph, and nerves It is through the walls of these cells that the material of which milk is made is taken and it is in these cells that milk is manufactured The milk passes from the cell into the lumen of

the aveolus and out into the duct system. A large number of alveoli draining into a common duct forms a small lobe. A comparison may be made by considering these alveoli as grapes and the ducts as the branching stems. A group of alveoli, corresponding to a bunch of grapes, is called a lobule, and a group of lobules forms a lobe.

These various divisions of the gland tissue are surrounded and supported by bands of connective tissue. Sometimes the connective tissue develops excessively and forms a large fibrous udder, often called a "meaty udder." Such udders, on account of their size, often give the impression that the cow is a heavy milker. This may not be so, as this connective tissue does not aid in milk secretion. An udder with less connective tissue and more secretive tissue is to be preferred.

Milk secretion occurs in the layer of epithelial cells lining the alveoli. These cells increase in size during the period between milking. The ducts of the udder, lined by two layers of epithelial cells, act as a storage for the milk between milkings.

THE MODE OF MILK SECRETION

As has been shown, the tiny epithelial cells in the alveoli are the factories in which the constituents carried by the blood are taken out of the blood capillaries and are synthesized (when necessary) into the component parts of milk: namely, fat, lactose, protein, minerals, vitamins, and all the other constituents of milk. In some way as yet unexplained, these cells have the unique ability of changing or manufacturing materials entirely different from those from which they came. It has been shown, as would be expected, that, as the blood passes through the udder, the content of amino acids, glucose, and fat in the blood appreciably decreases.

It is believed that each cell in the alveoli can manufacture all the milk constituents and that there are no specialized cells for each type of compound. The gradual synthesis of milk causes the epithelial cells to lengthen, and fat globules begin to collect in the end of the cell facing the inside cavity, or lumina, of the alveolus.

The opinion of investigators differs concerning the method by which the milk, when secreted, passes from the cells of the alveoli to the ducts Some believe that the milk constituents, by the process of osmosis and dialysis pass through the cell wall, leaving it intact Others believe that the cell wall ruptures to let the milk constituents escape

Effects of Pressure on Milk Secretion After the milking process as soon as the milk is removed from the udder the cycle of milk secretion and discharge by the epithelial cells begins, filling the lumina of the alveoli, the ducts, and the milk cistern During the first period the secretion is rapid but as soon as the storage spaces fill up, the pressure increases and secretion slows down Milk is not formed as rapidly as it was when the udder was empty or nearly so This explains why heavy milking cows will secrete considerably more milk if milked 3 or 4 times per day than they will if milked only twice With cows not milking heavily, the increase of milk production due to increased number of milkings is not so great as with the heavy producers When milk is left in the udder without removal until the maximum pressure has developed, it will be resorbed by the blood

Milk Secretion—a Continuous Process That milk secretion is a continuous process has been shown by several investigators Cows have been slaughtered immediately before the usual milking time, their udders have been removed, kept at body temperature, and milked thoroughly in the usual manner An experiment * conducted along this line yielded 70 per cent as much milk as was obtained in the corresponding previous milking. In one experiment, the udder was removed as described above and analyzed for lactose, with the result that more lactose was obtained than was contained in the milk yielded in the previous corresponding milking. This was due perhaps to the fact that it is almost impossible to obtain all the milk from an udder by ordinary milking.

MILK FORMATION

In feeding cows for milk production it must be borne in mind that the same type of food is used for milk production as for

* *J Agr Research* 45 401

growth and maintenance, and that the mammary gland has the ability to take the food from the blood and change it into the constituents of milk. Many of the compounds found in milk are different from those found in feed or in the cow's body. The cells in the udder are able to synthesize many of the individual milk constituents.

Proteins. The three principal proteins in milk are casein, albumin, and globulin. Casein, the principal protein, is unique in that it is found nowhere else in nature, and the albumin differs from that contained in the blood. Just how these are synthesized is not known but the evidence seems to indicate that the milk protein comes from the nonprotein nitrogen containing substances of the blood. The globulin in the milk is the same as is that found in the blood, and hence may be obtained directly from the blood.

Milk Sugar or Lactose ($C_{12}H_{22}O_{11}$). Milk sugar is formed by the union of two simple sugars, glucose and galactose, and, like casein, is found nowhere else in nature. In the past it was thought that the milk gland was able to change glucose found in blood to galactose. However, it has been shown that lactic acid is an essential part of this change, and that probably the mammary gland uses two molecules of lactic acid and one molecule of glucose to form one molecule of lactose. When lactose is injected into the blood stream it is not used by the mammary gland but is excreted in the urine.

Fats. Milk fat is a mixed fat composed of the glycerides of ten or more fatty acids and contains the whole series of fatty acids, beginning with those of low molecular weight and continuing to those of higher molecular weight characteristic of body fats. The fatlike substances of blood include neutral fat, fatty acids, phospholipids (lecithin), and cholesterol. Recent evidence indicates that milk fat is made from the triglycerides of the blood. Many of the fats found in milk are found nowhere else in the body, and hence they must be synthesized in the cells of the udder.

Minor Constituents. The minerals found in milk are also found in the blood and are probably taken out as the blood passes through the udder. They may be used in organic combinations or as they exist in the blood. The mammary gland is capable of removing most of the calcium from the blood faster than it can

be replenished from the calcium stores of the body This may cause milk fever, which sometimes occurs after parturition The injection of calcium gluconate or other calcium salts into the blood stream usually results in complete recovery

The vitamins, also, are not synthesized by the mammary gland but pass directly into the udder from the blood stream

"LETTING DOWN" THE MILK

As has already been pointed out, the secretion of milk is a continuous process, so that *most of the milk secured at any milking is present in the udder when the milking starts* Most of it is still held in the alveoli, although the milk cistern and the ducts leading to the cistern may also be filled Each alveolus is so small that it will hold only a fraction of a drop This milk held in the alveoli cannot be removed until the proper stimulus has been applied, which causes the cow to "let down" the milk This is an entirely involuntary act on the part of the cow but is caused by the action of a hormone called oxytocin, secreted by the pituitary gland, situated at the base of the brain

When the proper stimulus is applied, which may be done by washing the teats with warm water, nerve messages are carried to the brain, which causes the hormone to be ejected into the blood stream It is then carried to the udder where it causes the *muscles surrounding the alveoli and small ducts to contract*, thereby releasing the milk which flows down through the ducts into the cistern This then is known as the "let down" of milk It is necessary that the milking take place quickly after the "let down" occurs, for since the pituitary gland secretes the hormone for only a few minutes, its effect is soon lost Only about 45 seconds elapse from the time the stimulus is applied until the "let down" action occurs Unless the cow is properly stimulated and the milk is quickly removed, all the milk cannot be secured

Sometimes, because of some excitement or fright, the cow fails to give down her milk even though she has been properly stimulated It is often said that the cow "holds up" her milk It is impossible for a cow to willfully "hold up" her milk The action is entirely involuntary and is caused by another hormone, adrenalin, produced by the adrenal glands which cause the blood vessels to

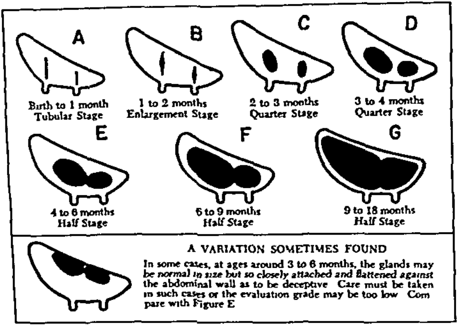
contract, thus slowing down the action of oxytocin. Loud noises, barking dogs, painful sores, and even strangers around the barn may cause cows to hold up their milk. Unkind treatment, such as kicking or beating a cow, is almost sure to cause a cow to "hold up" her milk. Irregularity of feeding or of milking may also be a cause. This is entirely involuntary on the part of the cow, and when it does occur it is useless to continue milking until the cow has calmed down. *Cows handled gently and regularly will seldom "hold up" their milk.*

The stimulation to "let down" the milk may be given in a great number of ways, although the washing with warm water is probably the one to which one should try to condition the cows. Such things as the sucking of the calf, or even the sight of a calf, the manipulation of the teats and udder, or even the rattling of the milk pails may cause the cow to "let down" her milk. This will be considered further in the discussion of proper milking procedure in Chapter 17.

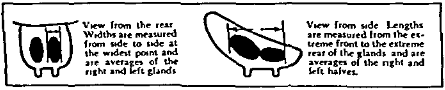
THE DEVELOPMENT OF THE MAMMARY GLAND

Early Development. At birth, the udder and teats of a calf are well developed, but there usually is very little glandular tissue. Studies have been made beginning soon after birth of the calf and continuing to 18 months of age, to determine the significance of the mammary gland development in calves as to their future producing capacity. It was found that the external appearance of an udder may be very deceptive, since some udders that seemed well developed had little glandular tissue whereas others that apeared small had well-formed glandular tissue. These studies were made on the Jersey and Holstein breeds. The glands, as shown in Fig. 6, were in the average calf only in a tubular stage during the first month. These glands start to grow and at about the age of 4 to 6 months the quarters on each half seem to join. The development of the udder as to size and stage at various ages was used as an index of the development of the udder as compared to average values. Grades ranging from 1 for the most retarded to 9 for the most developed were established. It is fairly easy to divide the udders into three classes: above average; average; and below average. The results indicate that

the most significant grades were the ones assigned when the calves were about 4 (3 to 5) months of age. Whether this will become an important method of culling a herd at an early age is



Drawings showing mammary gland development in heifer calves of different ages, from right side of udders.



How mammary gland measurements are made.

FIG 6 Mammary gland development in heifer calves (*Swett*).

not now known. The early results show that the mature equivalent production of the cows in the three upper grades, when calves, was some 2000 to 4000 pounds of milk greater than the production of those in the below average group of 1, 2, and 3. (Data obtained in herd of Bureau of Dairy Industry, Agricultural Research Administration, United States Department of Agriculture)

Later Development. Closely associated with the development of the udder and with milk secretion are certain hormones. Until the animal becomes sexually mature the ducts do not lengthen to any great extent, but when the animal first comes into heat the ducts start to lengthen.

Estrogen. This inward growth is caused by the estrogenic hormone, estrogen, the same hormone that causes animals to

FIG 7. External change in the udder of a heifer during the first pregnancy (*Turner*).

come in heat. This hormone is secreted by the cells of the ovary into the follicular fluid, from which it passes into the blood It stimulates the growth and branching of the milk ducts that lead out from the milk cistern. This seems to be done indirectly, as it actually stimulates the anterior pituitary to secrete a hormone or hormones to act upon the udder. Eventually it is excreted from the body through the urine. With each successive heat period these ducts increase in size, but there is no development of the true secreting tissue, the alveoli. The duct system at this stage of growth is like the trunk and larger branches of a leafless tree.

Progesterone. After the heifer conceives, a rapid growth and extension of the duct system to all parts of the udder occurs. Many side branches form, upon which the alveoli develop This growth is like the leafing out of a tree in which the alveoli repre-

sent the leaves and the ducts the branches of the tree This en largement and growth is caused by a second hormone proges terone which works in combination with estrogen It is secreted by the corpus luteum or "yellow body" in the ovary of the preg nant animal About 24 to 36 hours after the heifer comes into heat, the egg or ovum is discharged and carried into the fal

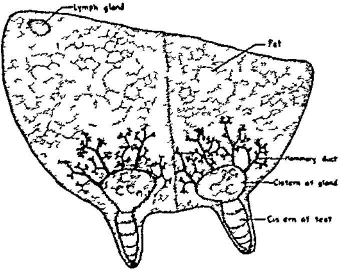


FIG 8 Diagram of a cross section of the udder of a heifer before reaching maturity At this stage the glands consist of a small teat and milk cistern. The ducts leading out from the cistern are small and short with few branches (*Turner*)

lopian tube down which it passes into the uterus where it may be fertilized After the discharge of the egg or ovum there is a rapid growth in the ovum follicle of a cell containing a deep yel low or orange pigment This is known as the corpus luteum or yellow body If the heifer is not bred this soon disappears and new cells secreting the estrogen develop but if she conceives the corpus luteum is retained in the ovary during pregnancy and secretes the hormone progesterone

Lactogen, or Galactin The enlargement of the ducts and the development of the alveoli continue until about the middle of pregnancy when their growth has largely been completed The cells of the alveoli then begin to secrete a fluid resembling colos trum milk the milk first secreted after a cow freshens This se

cretion of milk is brought about by a third hormone,* the lacto genic hormone, known as lactogen, or galactin This hormone is secreted by the anterior lobe of the pituitary gland located at the base of the brain During the latter half of the gestation period little growth takes place, but the enlargement of the udder is

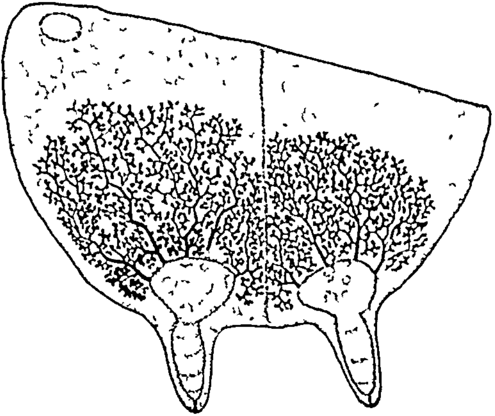


FIG 9 Diagram of a cross section of the udder after many "heat periods" The duct system shows extensive development but the lobule alveoli system is not stimulated to growth (*Turner*)

largely due to the accumulation in the duct system and alveoli of the secretion which is later given in the form of colostrum milk after the animal freshens

The mechanism that initiates the stimulus for milk secretion during the second half of pregnancy, yet holds in check the extensive secretion of milk until parturition occurs is not fully understood, but it is supposed that some substance in some way acts as a check until after parturition, at which time it disappears, giving the lactogenic hormone a chance to act fully

* *Mo Exp Sta Res Buls* 158 and 190

During the normal lactation period the yield of milk increases for a few weeks after calving, and then gradually decreases until the cow is dry. As the period of lactation advances the cells in the outer zone of the udder cease to secrete milk, while those

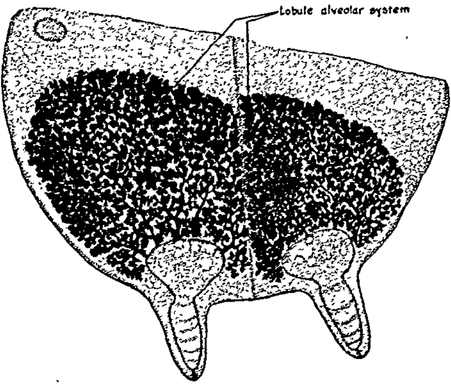


FIG. 10. Diagram of a cross section of the udder of a heifer at about the fifth month of pregnancy. From the ducts shown in Fig. 9, the lobule-alveoli system has grown, because of the combined stimulus of estrogen and progesterone (*Turner*).

around the larger ducts are still active. When the cow finally becomes dry, the alveoli become very small, leaving only the milk cistern and duct system. This is rebuilt during the dry period.

IMPORTANCE OF THE PITUITARY GLAND IN MILK SECRETION

The pituitary gland, also known as the "hypophysis," is a small structure located near the base of the brain. It is made up of three parts: the anterior lobe, the intermediate lobe, and the pos-

terior lobe. This gland secretes other hormones besides the lactogenic hormone, which have pronounced physiological effects upon the animal. A hormone secreted by the anterior lobe controls the growth and development of the animal, thus determining its mature size. Another hormone secreted by the posterior lobe stimulates the contraction of the involuntary muscles. Still other hormones secreted by this gland seem to influence the activity of the thyroid gland, the adrenal gland, and the metabolism of carbohydrates, fats, and proteins. Thus, by speeding up and regulating the body processes, these hormones indirectly influence milk production of dairy cows. That such is true has been shown by several investigators. The injection of the pituitary hormone into dairy cattle has resulted in an increased milk yield in certain series of as much as 7 or more liters of milk per day. The increase was temporary but was sufficient to more than pay for the cost of the injection. The effect seemed to be greatest with well-fed cows and during the first half of the lactation period. No bad effects of any kind were noted in any cow.

The difference in the productive ability of dairy cows might be explained by the difference in the amount of hormones secreted by the pituitary gland and by the other glands regulated by the pituitary.

Although the secretion of milk is an involuntary act, the nerves in the udder do have an influence on lactation. The stimulus of milking causes the discharge of the lactogenic hormone and thus prepares for the stimulus of milk secretion during the interval between milking.

Thyroactive Lactation Stimulant. It was found that thyroxine, a hormone secreted by the thyroid gland had a stimulating effect upon metabolism and milk secretion. Later it was found that an iodinated protein prepared under carefully controlled conditions had the same effect on milk production as thyroxine. This product has been made commercially and is found under several names, such as "iodinated casein," "thyroprotein," and "protamone." It has been found * that this material fed at the rate of 15 grams per day sometimes increases the milk production in the declining phase of lactation from 5 to 20 per cent and the butterfat production from 25 to 50 per cent. This is accompanied by an increase in respiration and pulse rate and a decrease in body

* *J Dairy Sci*, 27:385 (1944).

relative to corn stover as have been made concerning corn fodder It is even less palatable than corn fodder, and is very low in protein Its feeding value is about the same as that of timothy hay Sometimes it is shredded Although this does not increase its digestibility, it does decrease the waste and makes it much easier to store and handle, also, the refuse can be used as bedding

Millets. Millet ranks about the same as timothy in feeding value It is less palatable, however, especially if allowed to become too ripe It should be cut when in bloom, but at best is not a desirable feed for dairy cattle It is used principally as an emergency crop

Straws The feeding value of straws depends largely upon the method of growing and handling them When grain is allowed to become entirely ripe, its straw is of little value for dairy cows in milk When cows are fed on straws that are low in energy and digestibility, and are unpalatable besides, the best results cannot be expected Straw, especially oat straw, may be given in limited quantities to young stock and breeding animals Oat straw is to be preferred to all other straws, because it has the softest and most pliable stems and is more leafy than the others but it is low in protein, constipating, and unpalatable, it is used only for bedding in the best dairies Barley straw is sometimes used for feeding When barley straw of the bearded variety is fed it is necessary to watch the cow's mouth to detect the accumulation of beards which may penetrate the sides of the mouth sometimes causing infection Wheat straw and rye straw have no place in the feeding of dairy cattle but make excellent bedding

Sudan Grass. When cut early, Sudan grass makes a fairly good hay It yields heavily and is fairly palatable It is slightly laxative It compares favorably with other nonlegume hays in feeding value When allowed to become too ripe, it is woody and not as palatable or as nutritious as when cut early Often, two crops can be harvested per year It is used for hay, principally as an emergency crop

Timothy Timothy hay although one of the most common roughages fed to dairy cows, is, as ordinarily harvested, low in protein, minerals and vitamins It is not very palatable and is constipating in its effects When timothy is cut early, however, and from fields that have been nitrogen fertilized, it is much

higher in protein and much more palatable than the ordinary timothy hay. It cannot equal alfalfa or clover hay but may be used where these cannot be grown satisfactorily or economically. It is often grown with clover or alfalfa, the resulting hay being known as mixed hay, the feeding value of which is higher than that of timothy hay.

Other Grasses. Many other grasses, such as Reeds Canary grass, Johnson grass, Italian rye grass, brome grass, fescues, quack grass, bluegrass, and redtop, are sometimes used for hay. When cut early and well harvested, they make hays very similar in palatability and feeding value to similarly cured timothy hay.

SUCCULENTS

It is usually recommended that some kind of succulent feed should be added to the dairy-cow ration for most profitable results. A succulent feed contains a high percentage of moisture, is palatable, as a rule, and has a good physical effect on the cow. These feeds, however, are low in nutritive value because of the fact that they are so high in water content. They are especially valuable because of the high yield of total digestible nutrients which they give on the acre basis.

SILAGES

Corn Silage. Of all the crops used for the making of silage, corn is the most common. It can be harvested and put into the silo more easily, and is more certain of keeping than silage made from most of the other crops. Corn is as high in total digestible nutrients as any other crop used for silage, but it is low in protein. The moisture content of silage is high, averaging 74 per cent, leaving only 26 per cent dry matter. It is very palatable and is laxative in effect. It is low in minerals, however, and is not as high as might be expected in vitamins. It is not usually fed as a sole roughage, but should be combined with some legume hay that will help make up its deficiency in proteins, minerals, and vitamins. Three pounds of silage is usually fed to replace 1 pound of hay.

excellent quality, and is the highest of all common feeds in calcium When properly cured, it is rich in carotene, the precursor of vitamin A

Canada Field Peas. Field peas are sometimes grown (either by themselves or more commonly with oats) for hay in the northern states When cut at the proper time they make a very nutritious feed, somewhat higher than red clover in protein but not so palatable

Clovers Clover hay has the same advantages as alfalfa hay, except that it is a little lower in protein and is slightly less palatable Five kinds of clover are grown extensively in the United States alsike, crimson, red, ladino, and sweet All have about the same feeding value, but alsike is finer in the stem, which makes it especially well adapted for feeding young calves Ladino clover is primarily a pasture plant but mixtures of it and some grasses are sometimes used for hay Sweet clover is hard to cure properly, and should be cut when the first blossoms appear, as the stems rapidly grow woody after this stage is reached Although it has about the same analysis as the other clovers a much larger portion is usually refused by dairy cattle It has been noted that when sweet clover is fed to cattle it may cause the loss of the clotting power of the blood Animals fed heavily on sweet clover hay, especially when moldy, will sometimes bleed to death from internal hemorrhages or from outside wounds, such as dehorning or castration

Cowpeas Cowpea hay, when properly cured, provides a roughage that is even higher in protein than clover or alfalfa It makes a good roughage for the southern part of the country, and is adapted to warm climates

Lespedeza Lespedeza has been grown principally in the South and is adapted to land too acid or too poor to grow alfalfa or clover Certain varieties have been developed that will grow farther north than the common lespedeza Korean lespedeza, for example, is earlier and larger than the common variety and will grow farther north Lespedeza hay is well liked by dairy cattle and is fairly high in protein and total digestible nutrients, but as a rule the yield is not high The perennial species, *Lespedeza sericea*, is not as palatable as the annual, and since it is inclined to be stemmy, there is a greater waste

Soybeans. Soybean hay, when properly cured, makes a good roughage for dairy cattle. It is slightly higher in protein and total digestible nutrients than alfalfa, but it is usually coarser, and for this reason more is wasted. It is also high in calcium. It is very palatable when cut at the proper time but, when allowed to get too ripe, has coarse, woody stems which the cows will refuse. It is slightly constipating in its effect. Its chief disadvantages are: first, that it is hard to cure properly; and second, that the cost of growing is usually higher than that of alfalfa since it must be seeded each year. However, it can be grown in some places where alfalfa cannot. It is often seeded with Sudan grass, sorghums, or millet, in order to secure a higher yield.

NONLEGUME ROUGHAGES

In general, nonlegume roughages are not recommended as feed for dairy cows. They are low in protein, not very palatable, and are usually deficient in minerals and vitamins. They are used often, however, because of the ease with which they can be grown, and because otherwise they would be wasted. Since they do have some value, it is usually better to feed them than to allow them to waste. They can be fed successfully in conjunction with a legume hay and a high-protein grain ration.

Cereal Hay. All the cereals—oats, wheat, barley, and rye—are sometimes used as hay crops. When cut early and well cured, they are fairly palatable and resemble timothy hay in composition. They are low in protein, and hence for dairy cattle should be fed with a protein supplement. Oats and barley make a more palatable hay than wheat or rye.

Corn Fodder. Corn fodder, which includes both the grain and the stalk, is not entirely satisfactory as a feed for dairy cattle, especially if they are to be fed in the barn, since it is difficult to feed in the mangers. Because of its bulkiness, it is usually fed out-of-doors. It is unpalatable, low in protein, and is about equal to timothy hay in its nutritive value. There is considerable waste in feeding it as cows will not eat the coarse stalks, and much of the value of the grain is lost.

Corn Stover. Corn stover is corn fodder from which the ears have been removed. The same general statements can be made

weight This material is now being incorporated in certain commercial feed mixtures Just what the effects of the continued use of this material will have upon the length of life and well-being of dairy cows is not known But it does not seem that dairymen have as yet developed herds sufficiently well-bred to warrant the use of stimulants that may result in harmful effects as well as in higher milk and butterfat production It is against the rules of the breed associations to feed this material to cows on official test

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6

Selection of Feeds

In order to feed dairy cattle most efficiently, it is necessary to know the characteristics and properties of some of the more important dairy feeds. The selection of feeds is important both from the standpoint of economy of production and from that of the health of the animals.

It is always best to use as many home-grown feeds as possible, and to buy only what is necessary to balance them properly. By this method the crops can be disposed of directly to the cow, and thus the expenses and losses due to marketing are avoided; and profits, which would otherwise be absorbed by purchasing feeds, are saved.

Feeds can be divided into two great classes, (1) roughages and (2) concentrates. The roughages consist of silage, hay, and all the other coarse, bulky portions of the ration. The concentrates include the cereal grains and a great number of by-products of the milling and other industries.

LEGUME ROUGHAGES

Legume hay is especially valuable as a feed for dairy cows. This is due to the fact that it contains a liberal amount of high-quality proteins, a large percentage of calcium, and when well cured is rich in vitamins A and D. Some legume hay can be grown on almost any farm. By its use the cost of milk production can be kept down, since grain rations lower in protein content can then be used successfully.

Alfalfa. Alfalfa hay is one of the very best roughages for dairy cattle. It is very palatable, and it has a good effect upon the digestive system, as it is slightly laxative. It is high in protein of

relative to corn stover as have been made concerning corn fodder It is even less palatable than corn fodder, and is very low in protein Its feeding value is about the same as that of timothy hay Sometimes it is shredded Although this does not increase its digestibility, it does decrease the waste and makes it much easier to store and handle, also, the refuse can be used as bedding

Millets Millet ranks about the same as timothy in feeding value It is less palatable, however, especially if allowed to become too ripe It should be cut when in bloom, but at best is not a desirable feed for dairy cattle It is used principally as an emergency crop

Straws The feeding value of straws depends largely upon the method of growing and handling them When grain is allowed to become entirely ripe, its straw is of little value for dairy cows in milk When cows are fed on straws that are low in energy and digestibility, and are unpalatable besides, the best results cannot be expected Straw, especially oat straw, may be given in limited quantities to young stock and breeding animals Oat straw is to be preferred to all other straws, because it has the softest and most pliable stems and is more leafy than the others but it is low in protein constipating, and unpalatable, it is used only for bedding in the best dairies Barley straw is sometimes used for feeding When barley straw of the bearded variety is fed, it is necessary to watch the cow's mouth to detect the accumulation of beards which may penetrate the sides of the mouth, sometimes causing infection Wheat straw and rye straw have no place in the feeding of dairy cattle but make excellent bedding.

Sudan Grass When cut early, Sudan grass makes a fairly good hay It yields heavily and is fairly palatable It is slightly laxative It compares favorably with other nonlegume hays in feeding value When allowed to become too ripe, it is woody and not as palatable or as nutritious as when cut early Often, two crops can be harvested per year It is used for hay, principally as an emergency crop

Timothy Timothy hay, although one of the most common roughages fed to dairy cows, is, as ordinarily harvested, low in protein, minerals and vitamins It is not very palatable and is constipating in its effects When timothy is cut early, however, and from fields that have been nitrogen fertilized, it is much

higher in protein and much more palatable than the ordinary timothy hay. It cannot equal alfalfa or clover hay but may be used where these cannot be grown satisfactorily or economically. It is often grown with clover or alfalfa, the resulting hay being known as mixed hay, the feeding value of which is higher than that of timothy hay.

Other Grasses. Many other grasses, such as Reeds Canary grass, Johnson grass, Italian rye grass, brome grass, fescues, quack grass, bluegrass, and redtop, are sometimes used for hay. When cut early and well harvested, they make hays very similar in palatability and feeding value to similarly cured timothy hay.

SUCCULENTS

It is usually recommended that some kind of succulent feed should be added to the dairy-cow ration for most profitable results. A succulent feed contains a high percentage of moisture, is palatable, as a rule, and has a good physical effect on the cow. These feeds, however, are low in nutritive value because of the fact that they are so high in water content. They are especially valuable because of the high yield of total digestible nutrients which they give on the acre basis.

SILAGES

Corn Silage. Of all the crops used for the making of silage, corn is the most common. It can be harvested and put into the silo more easily, and is more certain of keeping than silage made from most of the other crops. Corn is as high in total digestible nutrients as any other crop used for silage, but it is low in protein. The moisture content of silage is high, averaging 74 per cent, leaving only 26 per cent dry matter. It is very palatable and is laxative in effect. It is low in minerals, however, and is not as high as might be expected in vitamins. It is not usually fed as a sole roughage, but should be combined with some legume hay that will help make up its deficiency in proteins, minerals, and vitamins. Three pounds of silage is usually fed to replace 1 pound of hay.

Corn Stover Silage. Silage from dry corn stover is sometimes made by cutting it up the same as the green corn and turning water into the silo, thus giving it a succulent nature The ears having been removed, the resulting silage is only slightly more than one half as good as regular corn silage

Grass Silage All kinds of grasses, grown by themselves or with legumes, are now being used successfully for silage A mixture of grasses and legumes is used extensively Such crops as wheat or rye and vetch, oats and peas alfalfa and timothy or brome grass or orchard grass, soybeans and Sudan, and many other such mixtures are being used successfully When the moisture is controlled or when they are ensiled with mineral acids, ground grains, or molasses, good silage with about the same feeding value as corn silage can be made

Legume Silage Clover, alfalfa, soybeans, and cowpeas are used successfully for silage, although in general they are not as easily ensiled as corn or grass They are higher in digestible protein but not quite as high in total digestible nutrients as corn silage They are more difficult to keep than corn silage, since they are not so rich in sugar, but when the moisture content is controlled or when special methods such as the addition of mineral acids, ground grains, or molasses is used, good silage can be made The methods of making silage will be described in a later chapter

Sorghum Silage The sorghums make excellent silage, especially if allowed to stand until the grain is in the dough stage They are palatable and have a desirable effect on the cow They will not yield quite so much as corn over most of the United States, but in the southern plain states they are used extensively

Sunflower Silage Sunflower silage has been used extensively in parts of the country where, because of dryness or shortness of season, corn cannot be grown to advantage The yield per acre is high, but it contains less dry matter and total digestible nutrients than corn silage It is not as palatable as corn silage, although cows soon learn to eat it It has only about 70 per cent as much food value as does good corn silage

ROOTS AND TUBERS

Carrots. Carrots are sometimes used as a feed for dairy cows, but their yield is so low that their use is not general. They are palatable, however, and being very rich in carotene, the precursor of vitamin A, they have a tendency to color the fat in the milk.

Mangels. Of all the root crops, mangels are the highest yielders and for this reason are the most commonly used. They are used extensively in Europe. Even though their yield is very high, they have a very low dry-matter content, averaging only about 9.2 pounds of dry matter in 100 pounds of mangels. In this country they are used especially for cows that are being forced for heavy milk production, and they are unexcelled in adding succulence to a ration. They are fed at the rate of 40 to 80 pounds per day, depending upon the size of the animal. They should be fed more generally, especially where there are too few animals to justify the use of a silo or where the tillable acreage is limited.

Potatoes. Potatoes have much the same general characteristics as the roots. They have about twice as much dry matter as roots but somewhat less than corn silage. They are low in protein and vitamins A and D and are not too palatable, but they can be fed with good success after the cows become accustomed to them. They are sometimes made into silage mixed with some dry roughage.

Sweet potatoes also can be fed successfully to dairy cattle. Dehydrated sweet potatoes have approximately 90 per cent as much milk-producing value as corn, or slightly more than corn-and-cob meal. This feed is high in carotene and will increase the carotene and therefore the yellow color in milk.

Rutabagas. Rutabagas have a little higher dry-matter content than mangels, and they keep a little better. In most of the United States they do not yield quite so well, however, and for this reason are not as widely grown. They require a cool climate. Unless care is taken they are likely to taint the flavor of the milk.

Sugar Beets. Sugar beets are slightly higher in total nutrients than the other roots, but the yield is much lower than that of either mangels or rutabagas and for this reason they are not gen-

erally used Beet tops are sometimes put in silos, where they make very satisfactory silage

Turnips The yield of turnips is lower than that of mangels or rutabagas and hence their cost of production is higher They are about equal in feeding value Care must be exercised in feeding turnips, however, since their flavor will appear in the milk

MISCELLANEOUS

Pumpkins (Field) The same general statement may be made of pumpkins as of the roots Pumpkins rank about the same as the roots in food value, but there is considerable labor in their preparation for feeding The idea that the seeds must be removed before feeding is erroneous, as they contain nothing injurious

Apple Pomace Apple pomace, the residue left in the making of apple cider or vinegar, is sometimes available to those who live near cider mills It gives about as good results as corn silage Apple pomace can be fed fresh as it comes from the mill or it can be put in the silo Dried apple pomace has somewhat less nutritive value than beet pulp and is less palatable

CONCENTRATES

It is possible to produce milk without feeding concentrates Some dairymen make it a practice to produce the greater part of their milk supply during the summer and to feed only roughage during the winter It is also possible to produce fairly large yields of milk by feeding only roughage consisting of silage and alfalfa hay, or even alfalfa hay alone To get a fairly large production, however, and to keep up the flow of milk over a long period of time, it is necessary to feed some concentrates The cereals and leguminous seeds, together with the by products, are known as the concentrates If some of the grains can be grown on the farm as they generally can be, they will usually be cheaper than purchased feeds

GRAINS

Barley. Barley is an excellent feed for dairy cattle. It can be substituted for corn, pound for pound, with equally good results. It contains a little more protein than corn but is slightly lower in total digestible nutrients. It is used quite extensively in countries and localities where corn is not available. When fed heavily, especially in conjunction with alfalfa hay, it is said to cause cows to bloat. However, this is not often serious. It should be ground to medium fineness for dairy cattle. If ground too fine it may become pasty in the mouth.

Buckwheat. The whole grain of buckwheat is not so desirable as its middlings, because of the large amount of crude fiber or hulls that it contains. These, however, give bulk to a ration and may be used when other grains in the ration are heavy. Buckwheat is not a very palatable feed, nor is it equal to corn as a dairy feed. Dairymen believe that buckwheat produces a hard, white butterfat.

Corn. Corn is grown on almost every dairy farm and should usually be included in the dairy ration. Not only is it highly palatable, but moreover it supplies a large amount of total nutrients economically. It is low in protein and also in minerals, therefore, some high-protein feed must be used in order to supply these deficiencies. Yellow corn has considerable carotene, the precursor of vitamin A, but white corn is lacking in this compound. It is usual to feed corn ground as a meal, although calves prefer cracked corn. Some of the commercial corn meal is made from that part of the kernel which remains after the manufacture of cracked corn or table meal. It is then correctly called *corn-feed meal.* It has about the same feeding value as corn meal.

Sometimes, whole ears are ground, making corn-and-cob meal This is used in some dairy rations in place of corn meal and may be valuable in adding bulk when other bulky feeds are not available. The cob is high in pentosans and therefore can be utilized, to a certain extent, by the digestive system of the dairy cow. It has been found that when fed to steers, about 2 5 pounds of cob were equal to 1 pound of corn meal.

When *corn is* purchased on the market it should be purchased on Federal grade which depends upon the amount of water and damaged grains that it contains According to the grade, the moisture in corn must not exceed 14 per cent in No 1, 15.5 per cent in No 2, 17.5 per cent in No 3, 20 per cent in No 4, and 23 per cent in No 5 Corn with more moisture than No 2 will not keep well in storage

Oats Oats are an excellent feed for dairy cattle and when not too high in price should be used in the dairy ration They are considerably higher in food value than wheat bran They are bulky, palatable, and higher in protein and mineral matter than corn, if they are home grown, the straw comes in handy for bedding Oats vary greatly in composition and should be purchased on guaranteed analysis Oats should be crimped, crushed, or ground to a medium fineness for dairy cows This is not neces sary for calves up to 8 months of age as they seem to prefer the whole grain

Rye Rye may be used in place of corn in a dairy ration It is nearly equal to corn in its food value, but it is not very palatable There may be danger in feeding it when it is infected with ergot When fed in large quantities it tends to produce butterfat with a hard body It can be fed safely up to one fifth of the grain ration when free from ergot

Wheat. When the price will permit, wheat may be substituted for corn in a dairy ration. It is a little higher than corn in feed ing value and is quite palatable Because of the small size and hardness of the kernels, the wheat should be ground before be ing fed Wheat, when fed alone, often forms a paste in the cow s mouth In a great many sections the cost prohibits its use in the dairy ration Wheat should not make up more than one third of the grain ration for heavy producing cows

LEGUMINOUS SEEDS

Soybeans The soybean is one of the important crops grown in this country It is extremely high in good quality protein and in fat and rather low in fiber It is also higher in total digestible nutrients than any of the cereals It is not high in minerals or vitamins, and is not too palatable It should be ground for

dairy cows, an operation that is often difficult on account of its sticky nature. However, when mixed with other grains, it will grind easily. It is likely to turn rancid after grinding if stored too long, especially during warm weather.

Field Peas. Field peas sometimes are grown in the cooler parts of the United States as feed, but on account of their low yields are not extensively used. They are medium high in protein of only fair quality. They are low in calcium and vitamins, but are quite palatable and can be used satisfactorily.

Cowpeas. Cowpeas are not extensively used because the seed ripens unevenly. They can, however, be fed satisfactorily to dairy cattle. In composition and characteristics they are very similar to field peas.

BY-PRODUCTS

Many industries have by-products that can be used as cattle feed. Some of these by-products are high in quality and food value; others have but limited value.

Milling Industry

Buckwheat Middlings. Buckwheat middlings is a by-product of the buckwheat-flour industry. It is fairly high in protein, and, when it can be purchased at a reasonable price, makes a very good dairy feed. It should not be mixed with the hulls, which are worthless as a dairy feed.

Wheat Bran. Wheat bran is one of the best of the milling products for feeding dairy cattle. It is palatable, bulky, and acts as a mild laxative. It also has a cooling effect, which makes it very useful as a feed for cows after calving. It is the highest of the common feeds in its phosphorus content. It is desirable in any ration for dairy cows when the price is not too high. It is of especial value to cows just before and after calving. It is also a good feed for calves and heifers. Standard bran contains some of the finely ground screenings.

Wheat Middlings. In the manufacture of flour, the finer particles of bran and some of the flour are collected and sold as standard middlings or shorts. They are higher in both protein

and total digestible nutrients than wheat bran but are not as desirable for feeding dairy cows They are not as bulky or as palatable as bran They are rich in phosphorus but low in calcium and the vitamins They are quite heavy and have a tendency to form into a sticky mass when wet

Oil Industry

Cottonseed Meal Cottonseed meal is the residue from the extraction of oil from the cottonseed, and is sometimes sold in cake form although the cake is usually ground and the product sold as meal Several grades of cottonseed meal are on the market Where transportation is an item of cost, the highest grade is usually the cheapest and best to purchase Formerly, this feed was the most commonly used high protein feed In the South it furnishes protein in the cheapest form of any of the concentrates and even in the North it often is one of the most economical protein supplements However, it is not too palatable and is low in calcium and vitamin A It contains a poison known as "gossypol," which makes it injurious when fed in large amounts to young calves and other animals With dairy cattle however, "cottonseed injury" seems to be caused by a lack of calcium and vitamin A. When good alfalfa hay or plenty of good quality hay of other kinds are fed "cottonseed injury" will not occur

Sometimes the hulls are ground and mixed with the feed and sold as cottonseed feed This is not nearly so nutritious as the meal, since the hulls are practically worthless as dairy feed

Linseed-Oil Meal This high protein feed is the residue left after the linseed oil has been extracted from the flaxseed In its manufacture two processes are used, one known as the old process, produced by the expeller or hydraulic method, and the other as the new, or solvent, process The old process consists in crushing the seeds heating them to a high temperature, and removing the oil under high pressure In the new process the seeds are treated in the same way except that the oil is extracted by being dissolved in a fat solvent instead of by pressure The difference in the methods of extracting the oil results in a slight difference in the composition of the residue from which the linseed

meal is made. The new-process meal is slightly richer in protein but lower in energy value. These feeds are sometimes called "oil meal." They are more palatable than cottonseed meal, are slightly laxative in effect, and seem to brighten the coats of the animals to which they are fed and to keep them healthy. They are especially valuable when nonlaxative feeds are fed. When the price is not too high, they may be used advantageously in small quantities in the ration of dairy cows. They tend to produce a soft butter and hence are valuable in rations which would otherwise produce hard butter.

Soybean-Oil Meal. The production of soybeans has been increasing greatly, so much so that soybean-oil meal is now the most important high-protein supplement. Soybean-oil meal is the residue after the oil has been extracted from the bean. It is rich in protein of high quality. It is palatable and slightly laxative in effect. Soybean-oil meal made by the expeller or hydraulic process is preferred to that made by the solvent process, since it is considerably higher in fat. This is especially true if other feeds in the ration are low in fat. It is being fed in large amounts to dairy cattle and is well liked by the feeders.

Peanut-Oil Meal. Peanut-oil meal, a by-product of the manufacture of peanut oil, is well liked as a dairy feed in sections of the country where it is available. It varies considerably in composition, but first-grade peanut-oil meal is very high in protein, is palatable, and has a slightly laxative effect upon the cow. It is not extensively used as a dairy feed but is very satisfactory when it is available. It tends to become rancid in warmer weather when stored very long.

Cocoanut-Oil Meal. Cocoanut-oil meal (copra-oil meal) is the residue from the manufacture of oil from the cocoanut, and is made by the two processes that have been described in connection with linseed-oil meal. The old process is slightly lower in protein than the new one, but is higher in total nutrients. Cocoanut-oil meal is higher in feeding value than wheat bran, but not as high as many of the other oil meals. It has a tendency to turn rancid in warm weather.

Brewing and Distilling

Brewers' Grains Brewers' grains are a residue from the brewing of barley in the making of beer and certain "soft" drinks. After the sugar is extracted the grains are dried and sold as dried brewers' grains. They are fairly bulky and, being medium high in protein, are often used to an advantage. They are, however,

SIMPLIFIED FLOW DIAGRAM

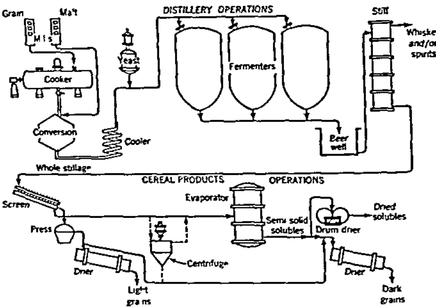

FIG 11 Diagram of the manufacture of distillers' feeds (*taken from Feedstuffs*)

low in digestible nutrients, high in crude fiber, and not very palatable. If the brewery is near by, many dairymen secure them wet. In this form they make a very satisfactory feed, but unless care is taken to have the feed boxes tight the liquid will run through and ferment, creating an undesirable odor in the stable. When the grains are given proper care and the feed boxes kept clean the wet grains can be fed without difficulty to dairy cows. They are often classified as a high protein silage, and can be fed in place of corn silage.

Distillers' Grains. In the manufacture of distilled liquors and alcohol from grain, the coarser particles are strained out of the watery residue (stillage), forming wet distillers' grains which, when dried, are called distillers' dried grains without solubles, or light grains. The water-soluble material that passes through the strainer, known as thin stillage or thin slop, is sometimes condensed and dried and forms dried distillers' solubles. The condensed solubles are sometimes added to the wet distillers' grains and this is then dried and called dried distillers' grains with solubles, or dark grains. Both the dark grains and light grains are medium high in protein and high in fat. They are highly digestible, although fairly bulky, and are equal to corn in total digestible nutrients. The chief difference between the light and dark grains is that the latter is much richer in the B-complex vitamins, which, however, is of little importance in dairy feeds. The rye distillers' dried grains are much lower in protein and in fat and higher in fiber and less digestible than the corn distillers' dried grains and hence not nearly as good a feed.

Distilleries are now using other sources of starch and sugar, such as molasses, grain sorghum, wheat, and potatoes. Distillers' dried grains from these sources are less valuable than from corn and should be purchased on the basis of their guaranteed analysis.

Starch Industry

Corn-Gluten Meal and Corn-Gluten Feed. Corn-gluten meal and corn-gluten feed are by-products in the manufacture of starch and glucose. The gluten of corn, separated from the starch, is dried and sold as corn-gluten meal; but when mixed with the corn bran it is known as corn-gluten feed. The meal is therefore richer in protein and total digestible nutrients than the feed, but not so rich in calcium or vitamin A. The protein is not of very high quality, and hence this feed should be given with other feeds which will make good this deficiency. Both are satisfactory when they can be purchased at a price that makes them cheap enough to include in the ration. The meal is heavy and should be mixed with some more bulky feed. Neither of them is as palatable as some of the other feeds. Since their protein con-

tent varies considerably, they should always be purchased on guaranteed analysis

Sugar Industry

Dried Beet Pulp. Beet pulp is the residue left after the sugar has been extracted from the sugar beet It is high in carbohydrates but low in protein and fat When silage or other succulent feeds are not available, dried beet pulp soaked with about 3 times its weight in water for about 12 hours before feeding makes an excellent substitute When the cows are given free access to water, however, equally good results are obtained if the beet pulp is fed dry It is highly palatable and has a very good physiological effect upon the cow Because of its bulky nature, dried beet pulp is especially valuable in feeding cows for heavy production

Beet pulp is used extensively for fitting animals for sales and shows and to feed while on the show circuit It provides a succulent feed to use under these conditions

Molasses Molasses is a by product of the manufacture of sugar from both beets and cane A crude syrup is produced that is often used in feeding dairy cows The molasses from cane is known as "blackstrap" Since these products are quite low in protein, they are essentially energy feeds Molasses is quite laxative and should not be fed in a quantity to exceed 2 or 3 pounds daily for each animal The customary way of feeding it on the farm is to dilute the molasses with water and sprinkle it over the feed It is commonly found in many of the commercial mixed feeds Molasses is often used to mix with feeds in order to give them palatability, which is one of its greatest values It is used extensively as a preservative in the ensiling of grasses and legumes.

Wood waste has been hydrolized with acids to produce wood molasses It has been fed to dairy cows and other animals experimentally, and within certain limitations may have a feed replacement value

Hominy Grit Industry

Hominy Feed. In the manufacture of hominy grits from corn, a by-product known as hominy feed is obtained. It has practically the same protein and carbohydrate content as corn, and may be used as a substitute for it. Practically the same things can be said of it as of corn for the feeding of dairy cows, although it is a little more bulky since it contains considerable amounts of corn bran. When it can be purchased as cheap as corn meal, it may well be used in the ration.

Oatmeal Industry

Oat-Mill Feed. Oat-mill feed is a by-product in the manufacture of oatmeal. The oat grain, when removed from the hull, leaves a tip attached to the hull. This, together with the hull, is ground into a feed which is high in fiber but low in protein and total digestible nutrients. It is often used as a substitute for roughage, but its analysis is not much higher than that of oat straw. When fed for a concentrate it must be supplemented with some high-protein feed. Sometimes it is mixed with molasses to make it more palatable.

Citrus-Canning Industry

Citrus Pulp. Citrus pulp is a by-product of citrus-canning factories, where fruit juices, fruits, and other products are canned. It consists of the peels, the inside portion and seeds, and sometimes the entire cull fruit. This is dried, ground, and sold as dried citrus pulp. It is sometimes used as a substitute for beet pulp, which it resembles in composition, although it is slightly higher in total digestible nutrients. It is not very palatable and the cows may require a short time to learn to eat it. It is high in calcium but low in phosphorus. It can be fed dry or it can be soaked with water the same as the beet pulp. Dairymen living near the canneries sometimes get it fresh and either feed it within a short time or ensile it.

The liquid portion of the citrus residue is often separated from

thoroughly and can incorporate molasses more easily and thoroughly than it can be done on the farm

Ready mixed feeds are of especial value to the dairyman who uses only a small amount of feed or who is so located that it is impossible for him to secure readily a variety of feeds for home mixing The buyer should always pay close attention to the guaranteed analysis, so that he may get his protein and total nutrients as cheaply as possible His decision as to the use of ready mixed feeds should depend largely upon the relative price If the dairyman however, has corn, barley, or oats on his farm, and needs a high-protein feed to balance these, he can usually purchase his protein cheaper in the form of one of the high protein supplements or he can purchase a high protein ready mixed ration.

Most of the commercial mixed feeds are sold with what is known as a "closed formula" The names of the ingredients are given but not the amounts of each. The farmer cooperatives and a few others have put on the market an "open formula" feed that lists on the tag not only the name but the amount of each ingredient. Such data are very helpful in computing a balanced ration. They have the disadvantage that it is not easy to change the formula when prices change rapidly, since it is difficult to have the tags changed.

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the other portion and concentrated It is called citrus molasses and has about the same composition and feeding value as blackstrap or beet molasses

Packing Plant and Fishing Industries

Tankage. Tankage is a by product of the packing plant It is a high protein feed of animal origin and has been used as a protein supplement for dairy cattle It is high in protein of an excellent quality and in calcium and phosphorus It is not particularly palatable to dairy cattle, but they soon learn to eat it if it is kept fresh When fed in limited amounts it does not seem to impart undesirable flavors to the milk.

Blood Meal and Flour. Blood collected at the packing plant is dried and sold as blood meal It is a very high protein feed, contains as much as 80 per cent protein, but it is low in calcium and phosphorus It is not very palatable A special process in which the blood is dried at a somewhat lower temperature has been used in the manufacture of a product known as a soluble blood flour, which makes an excellent feed for calves It is more palatable and more digestible than the ordinary blood meal It seems to have the power of keeping the digestive tract of a young calf free from disease

Fish Meal. Fish meal is made either from the entire fish, like the menhaden fish meal produced in eastern United States, or from the damaged fish and fish heads, as is done with the cod, sardine, salmon, and other fish of various regions Fish meal is a high protein feed and is rich in calcium and phosphorus The protein is of high quality When vacuum dried, it seems to be more digestible and contains more vitamins A and D It can be used for dairy cattle satisfactorily, although it should not be fed in excessive amounts since it may give the milk a fish flavor Many cows do not like it but usually will eat it mixed with other feeds It makes a good protein supplement for calves, on account of the high quality of its protein

Synthetic Feeds

Urea. Synthetic urea has been manufactured and sold as a nitrogenous fertilizer ingredient for some time. Research at many experiment stations has shown that it can be utilized by ruminants as a part of their protein requirements. Rumen organisms transform it into protein.

The urea that is on the market as a feed ingredient is a white crystalline product and is mixed with materials to prevent its caking. It is standardized to contain nitrogen equivalent to 262 per cent protein.

It is recommended that it be used not to exceed 3 per cent of the grain mixture.

Ready-Mixed Feeds

The manufacture and sale of commercial mixed feeds has become an important industry. A great number of ready-mixed feeds are on the market. Most are excellent feeds, made of good ingredients and mixed intelligently. In the past, some of these ready-mixed feeds were made of low-quality ingredients and were used as a means of disposing of some inferior product. Even today this is true for some of the competitive feeds. Most states now have laws requiring the labeling of each sack of feed with a tag showing the minimum percentage of protein and fat, the maximum percentage of crude fiber, and a list of the ingredients in the mixture. The amount of each ingredient is not required to be listed. At present many excellent ready-mixed feeds may be purchased.

The decision as to whether to buy a ready-mixed feed or to mix one on the farm depends upon the relative price, the convenience, and the labor available. There is probably no one best mixture for a dairy cow or for any other type of livestock. An excellent ration can be mixed on the farm, provided the necessary ingredients are at hand or can be secured, and provided there is a suitable place for doing the mixing. The feed manufacturers have the advantages that they can mix the feeds more

7

Desirable Characteristics of a Ration

In order that the feeds may be combined in such a way that the best results are obtained, one must not only be familiar with the characteristics of the individual feeds, but must also know what factors enter into the make up of a desirable ration A ration for a dairy cow should contain a liberal supply of net energy or total digestible nutrients, sufficient protein, sufficient fat, and an adequate supply of minerals and vitamins The ration also should be palatable, have a good physiological effect on the cow, and under normal conditions should have some bulk and variety It should also be low in cost as regards the nutrients it contains

WHAT BECOMES OF A COW'S FEED?

Milk, as has already been pointed out, contains the same compounds as the cow's feed, but in a different form Figure 12 shows how the elements unite into compounds to form the feed out of which animals manufacture milk and satisfy their bodily needs This figure shows that the dairy cow produces her milk entirely from the feed and water that she consumes, and that unless she receives sufficient of the right kinds of feed she cannot be expected to produce milk

EARLY SUMMER CONDITIONS THROUGHOUT THE YEAR

In the making of a dairy ration, it should be the aim to imitate as nearly as possible the feed conditions of early summer Every dairyman knows that the period of highest and most economical

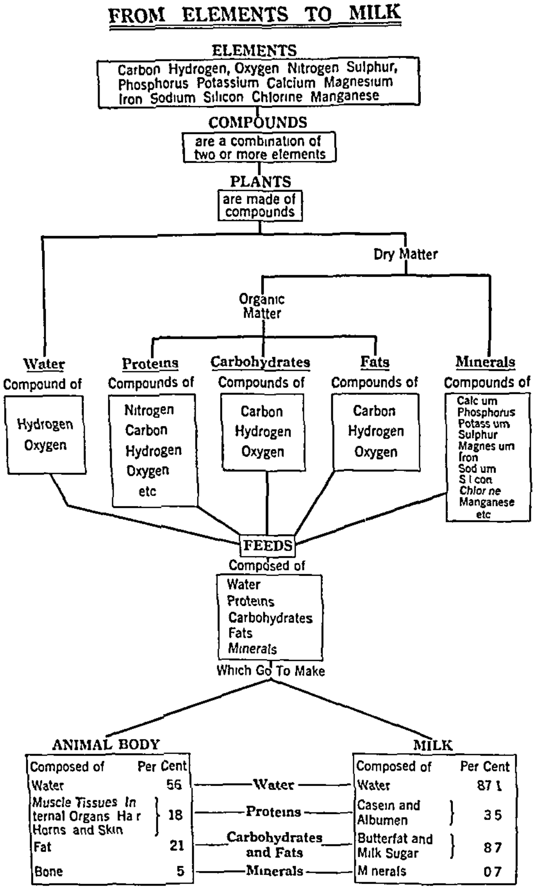

Fig 12 Chart showing interrelation of common component elements of plant and animal life that go to make up feed and finally milk

milk production is during the early summer months This fact is not hard to explain Early summer pasture provides for the dairy cow an abundance of palatable feed which is succulent in nature Having sufficient bulk and variety, it produces a good physiological effect upon the cow Pasture also contains plenty of minerals and is cheap

RIGHT AMOUNT OF FEED

An abundance of feed is the first essential in feeding cows for profit The primitive cow had only to care for herself and to feed her calf for a few months After freshening in the spring of the year, she could develop the calf and dry off in the fall, and her labors were practically done In these days the cow is regarded, especially in the best dairy sections, simply as a factory, and, as in any other factory, the cheapest production is possible only when the plant is being run to nearly its full capacity

A cow needs her food mainly for two purposes, namely, for the maintenance of her body and for the production of milk, although at times she may need it to grow a fetus or to put on weight. Young animals also need it for growth The feed requirement for the maintenance of the body is the amount necessary to keep the body in running order, that is, to perform such functions as pumping blood, breathing, chewing and digesting food, and making body repairs It has been shown that certain rather definite amounts of protein and energy are required for body maintenance, the amount depending upon the body surface of the cow, or for all practical purposes the weight of the cow

Figure 13 refers to a cow whose body weight is 1000 pounds and who is fed for three levels of production namely, 40 pounds, 20 pounds, and 10 pounds of milk per day It will be noted that the maintenance remains constant regardless of production The feed requirements for maintenance is very nearly proportional to the body surface or the size of the animal, irrespective of breed, age, or other factors It is true that a good dairy cow will draw on the reserve of her body to produce milk for a limited length of time Nevertheless, the factor for maintenance remains constant and this reserve must eventually be replaced from the feed,

otherwise the cow will become emaciated and her production will be diminished.

Figure 13 also shows that it is poor economy to feed sparingly. The feed required for maintenance remains the same, and unless the cow is fed enough for liberal milk production in addition to the requirement for maintenance, the proportion of food which goes to make the milk is less than it should be. A cow should be

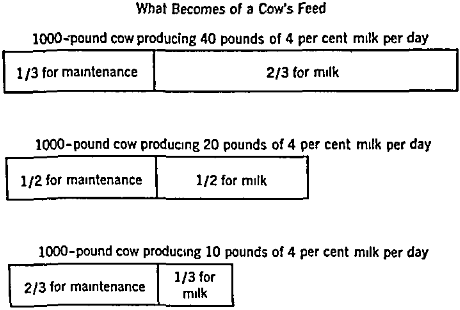

FIG. 13. Chart showing the percentage of feed required for maintenance by cows of different producing ability and the amount left for milk production.

fed practically to the limit of her milk-producing capacity. Aside from her feed and care, the limiting factor is the cow's inherent capacity for milk production. The 1000-pound cow producing 40 pounds of 4 per cent milk uses only one-third of her feed for maintenance and two-thirds for milk production. When, however, she is fed to produce only 20 pounds per day, she uses one-half of her feed for maintenance, leaving only one-half for milk production, and when she is fed for only 10 pounds of milk per day, she uses two-thirds of her feed for maintenance and only one-third for milk production. The economy of high production is emphatically illustrated.

Overfeeding. Most dairymen do not feed enough, but there are some who, being good feeders, and having cows in their herd that do not have the inherent ability to produce heavily, overfeed

them There is no economy in feeding a dairy cow more than she will return in the milk she produces If the above cow had the inherent capacity to produce only 20 pounds of milk per day, any extra feed consumed by her will be used for gain in weight Unless a cow is in poor condition, the gain in weight is of no value as far as milk production is concerned, unless it is used as a reserve that may be drawn upon at some future time

PROTEIN

A dairy cow must be given an adequate amount of protein or other nitrogen containing compounds for body repair and for milk production, since she cannot synthesize protein out of materials such as carbohydrates and fats, which do not contain nitrogen The amount of protein required by a dairy cow depends upon her body surface and the amount of milk that she is producing.

Fortunately, the dairy cow does not need to be supplied with the various amino acids in her feed, since the bacteria and other microorganisms in her rumen are able to use simple nitrogenous compounds and to build these up into complex proteins in their own body The proteins thus made can be digested further on in the digestive tract of the cow and can be made available to the cow These proteins from the bacterial cells may provide all of the essential amino acids, even though some of them may be lacking in the feed fed to the cow For this reason, the dairy cow does not require as complete proteins as animals with single stomachs Calves however, should be fed high-quality protein for the first few weeks after birth or until the rumen is developed and the bacteria flora therein established

Since protein feeds are usually higher in price than carbohydrate feeds, the amount fed is kept to the minimum Sometimes, however, the conditions are such that protein rich feeds may be cheaper than carbohydrate rich feeds, and then it may be profitable to feed a larger amount of protein than is actually required This, of course throws a heavy load on the liver and kidney in getting rid of the excess nitrogen, but it has been shown that heavy feeding of protein is not harmful to dairy cows, provided that they are given an adequate ration in other essentials The

excess protein is broken down and the nitrogen excreted, and the remaining portion can be used for energy.

The amount of protein required under normal conditions has been determined experimentally and is given in the requirements for maintenance and milk production in Table *B* in the appendix. The amount needed for growth has also been determined and is given in the same table.

CARBOHYDRATES

The carbohydrates of feed, consisting of the starch and sugars, called nitrogen-free extract, and crude fiber, make up the main portion of the ration of dairy cows. They provide both heat and energy. The amount required by the cow depends not only upon the body surface of the animal but also upon the amount of physical and productive work that the animal is doing.

As the amount of milk that a dairy cow produces increases, the amount of carbohydrates needed also increases. The amount required also depends upon the amount of protein and fat included in the ration. These two compounds can be broken down and utilized for the production of work. Since this is true, net energy or total digestible nutrients are generally used since they include the productive value of all three of these compounds. The carbohydrates are ordinarily the cheaper forms of feed and should be fed in large amounts, although not in such amounts that the dairy cow will not receive sufficient protein. The amount of crude fiber in a ration is an indication of its digestibility. With each per cent increase in crude fiber, the ration is reduced about 2½ per cent in efficiency.

FATS

A certain amount of fat is always found in the common feeds. These fats are used much like carbohydrates for the production of work, although they are so much more concentrated that they are about 2¼ times more efficient pound for pound than the carbohydrates. Carbohydrates, however, can be converted into fats; and so an animal could get along with a small amount of fat, provided that the ration is adequate in other essentials.

Experiments * have shown that for ordinary feeding a level of 4 per cent of fat in the grain mixture which is fed at the rate of 1 pound for every 3 to 3½ pounds of milk along with an adequate amount of hay and silage of good quality may be considered a good level for milk production A higher level is not justified if it increases the cost of the ration per unit of total digestible nutrients, and when fat is scarce and high in price the percentage may be lowered to 3 per cent without great loss in production or detrimental effect on the cow

MINERALS

The ration of a dairy cow must also be adequate in its mineral supply Minerals make up about 4 per cent of the weight of a cow (exclusive of the content of the digestive tract) and 78 per cent of this amount occurs in the bones Minerals have many important functions in the body, as has already been pointed out For many years the importance of feeding common salt (NaCl) and calcium and phosphorus when needed has been recognized Recently, the importance of certain "trace elements," such as iodine, cobalt, iron and copper has been revealed The necessity of feeding these trace elements is restricted to limited areas Although such deficiencies do occur, and may be corrected by the feeding of suitable mineral supplements yet, in general, the only mineral that usually must be added to a dairy ration is common salt

VITAMINS

In feeding dairy cattle it is important also that the ration contain a sufficiency of the various vitamins Under favorable farm conditions all the vitamins are generally furnished by natural feeds or are manufactured in the rumen in adequate amounts to meet the needs of dairy animals Under certain conditions however it is necessary to supplement vitamins A and D Only rarely is it necessary to furnish special sources of the other vitamins A discussion of the minerals and vitamins are contained in the following chapter

* *Cornell Exp St Buls* 543 and 593

PALATABILITY

To be palatable a feed must be pleasing in flavor so that the cow will like it. A cow will do her best when she relishes her feed. A ration may contain everything necessary for maximum production; yet, if it is not palatable, the cow may not consume enough of it to supply nutrients for her maximum production. One of the objects of feeding is to tempt the cow's appetite, thereby inducing her to eat up to the limit of her ability to produce milk.

Cows, like people, show individuality by different tastes and appetites. Certain feeds not eaten at all by some cows are relished by others. Cows can become accustomed to eating some feeds that do not at first appeal to them. It is known that palatability has little effect on digestibility. The advantage of palatable over unpalatable feeds is mainly that the cow will consume a larger amount, and, as has been pointed out, the economy of production depends largely upon the amount of feed that the cow will eat above what is necessary for her maintenance and within the limits of her inheritance to produce. If unpalatable feeds are to be used, they should be mixed with palatable ones. Molasses is sometimes mixed with unpalatable feeds to give them the desired palatability.

SUCCULENCE

A succulent feed is one that contains the natural juices of green forage similar to the natural juices of pasture grass. Although milk can be produced satisfactorily even without a succulent feed, if a good legume hay is fed and if water is available to the cows at all times, cows will usually consume more feed when the ration includes some succulent feeds. This is especially true if low-quality roughage is being fed. Some of the common succulent feeds are green grasses, silage, and roots.

BULK

A grain mixture is said to have bulk when a definite weight of it occupies a relatively large space. To illustrate: 100 pounds of

wheat bran occupies much more space than 100 pounds of corn meal, hence, it is said to be more bulky or lighter

Bulk is necessary in a dairy ration, but usually bulk is sufficient if the required amount of roughage is fed Formerly, it was thought that it was necessary to have a certain amount of bulk in the grain ration, otherwise the feed would form in balls in the digestive tract, the digestive juices would not penetrate, and the cows would go off feed Results of experiments * seem to indicate that the reason for such cows going off feed may not be a lack of bulk in the grain ration It has been found that all the grain mixture passes directly to the rumen or reticulum and is there mixed with the content of the rumen so that all balls of feed are broken up very soon after going into the stomach It is more necessary to have bulk in the grain mixture for high producing cows that are heavily fed than for cows that are fed only a small amount of the grain mixture Cows will more often go off feed when on heavy than when on light feeds

A good guide is to have the mixture weigh not more than 1 pound per quart Usually, this will be accomplished by using 40 per cent by weight of the bulky type feeds Fine grinding makes a feed heavier and unpalatable Medium grinding or crimping grains gives more bulk than fine grinding

Wheat bran, ground oats, corn and cob meal, dried brewers' grain alfalfa meal and beet pulp are common bulky feeds It is advisible to have a certain amount of bulk in the grain ration if the feeds are at hand or can be purchased so that the protein is no more expensive than that in other protein concentrates

VARIETY

In compounding a grain ration so that it will have palatability, three or four grains are generally used for the sake of variety It is a common belief that if a cow is kept on the same ration for a long period of time she will lose her appetite This, however, is not necessarily true If the ration contains variety and succulence and is palatable, the cows will do better without many changes Cows do not seem to tire of a monotonous diet Simple

* *J Agr Research* 44 789

home-grown rations containing only corn or corn and oats supplemented with some high-protein feed seem to give as good results as a mixture having much more variety, when fed with good-quality roughage or pasture.

For winter feeding two kinds of roughages are desirable: one, a silage or some other succulence; and the other preferably a legume hay, although good results have been obtained by the feeding of a legume hay by itself. The palatability and nutritiveness of such feeds are more important than the number of ingredients. Many feeders feel that grain rations containing a reasonable number of palatable feeds are apt to be better liked by cows than are those with only 2 or 3 ingredients. They usually prefer to have 5 or 6 different ingredients, especially for high-producing cows.

EFFECT OF HEALTH

Each feed has its own peculiar effect upon the animal body. The specific effects of all feeds are not known as yet, but certain effects of some of the feeds are established. Corn stover, for instance, is known to cause constipation, and wheat bran has a laxative effect. For these reasons, neither of these feeds should be fed in large amounts unless some feeds that have the opposite effects are fed with them. Some of the roughages, such as silage, clover hay, and alfalfa hay, are laxative; some, such as timothy hay, oat straw, and corn stover, are constipating. When the roughages are constipating in effect, a grain mixture of a laxative nature must be fed if the dairy cow is to do her best. For most efficient production, dairy cows should be fed rations that are slightly laxative in effect.

CHEAPNESS

The careful feeder will try to select cheap feeds, but in this he will not make the cost per ton the essential consideration. The important thing to be considered is the cost of 1 pound of digestible proteins and 1 pound of total digestible nutrients. It is well, from the point of view of economy, to make use of as many home-grown feeds as possible, and to purchase only what is necessary

to balance them properly If homegrown feeds are used the cost and labor of marketing is eliminated

AMOUNT TO FEED

Feeders should know the amount of grain and roughage to give their animals The digestive system of the dairy cow is especially adapted to consume large amounts of roughages, and she should be given plenty of bulky feeds The proportion of grain to roughage will depend largely upon the amount of milk the cow is giving Heavy milkers will consume much more grain in proportion to roughage than those that are not producing so heavily Usually, the poor to medium producers receive only about 25 to 30 per cent from their concentrates, whereas a good producer will receive from 40 to 50 per cent from her concentrates Exceptionally high producers may be fed as high as 70 to 80 per cent of their feed in their concentrates

The following general rules are given as a guide for the beginner in feeding to help him to use proper proportions of grain and roughages in his ration

Feed all the roughage that the cows will eat up clean This will usually be about 1 to 1½ pounds of hay and 3 pounds of silage to 100 pounds of live weight per day With no silage as much as 2½ pounds of hay may be fed Silage, alone, may be fed at the rate of 6 to 8 pounds daily per 100 pounds of live weight When beet pulp is used feed about 4 to 8 pounds of dry pulp per cow per day If preferred, it may be soaked in 3 times its weight in water Beets may be fed up to 60 or 80 pounds

The grain mixture should be fed in proportion to the milk yield As a general rule with a good roughage, high testing cows are fed 1 pound of grain to each 2½ to 3 pounds of milk, and low-testing cows 1 pound of grain to each 3½ to 4 pounds of milk. With poor roughage, the grain allowance should be increased A more exact procedure is given in Table XIII in Chapter 11

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8

Minerals and Vitamins

It has long been known that minerals and vitamins are necessary for the health and well being of an animal and even for maintaining life itself. The functions of minerals and vitamins in the body have already been discussed. Unless they are supplied either in the natural feed or otherwise, troubles will often appear. These troubles will consist of such conditions as (1) failure of the animal to grow to full size, (2) failure of cows to produce as much milk as they should, (3) failure of cows to breed regularly, (4) failure of the cow to carry her calf for the proper length of time, and (5) animals may become stiff and have enlarged joints. Of course, such troubles may be the result of disease or poor feeding in general, but if there is no disease and the feeding seems to be ample and there is yet trouble, then the lack of minerals or vitamins should be considered.

MINERALS

Animals appear to suffer more from a deficiency of minerals than they did in the early days. This is true for two reasons: (1) the amount of minerals in the natural feed, especially the roughage, is less than it was formerly. This is due first to the fact that the mineral content of the soil has decreased in the older farming sections, and more especially the trace minerals which are not added in the fertilizer, and, second, the use of heavy fertilizer with the resulting higher yields takes much more of these elements out of the soil than when such large crops were not grown, and (2) the production of the dairy cow has increased greatly, which increases the requirements for these minerals. Milk is rich in minerals, and if a cow produces more milk, the results are that more minerals must be supplied.

Minerals Most Likely to Be Deficient. The fourteen minerals required by an animal are sodium, chlorine, calcium, phosphorus, potassium, magnesium, sulfur, copper, iodine, zinc, iron, cobalt, manganese, and fluorine. The ones that are most likely to be lacking are sodium, chlorine, calcium, phosphorus, iodine, cobalt, iron, and copper. The so-called trace minerals are copper, cobalt, iodine, manganese, zinc, and fluorine. Other minerals found in the animal body but of little known importance, are silicon, nickel, arsenic, lead, tin, borax, and molybdenum. Some of these are found only in the spectrum. All the minerals are contained in varying amounts in the common feeds, but sometimes they may be lacking and additional amounts must be fed.

Reasons Why Feeds Lack in Minerals. Under average conditions of feeding and production, there is small chance of lack of minerals in the ration. Of course, sodium and chlorine (common salt) must be supplied to all dairy animals. A ration with a legume in the roughage to furnish the calcium and with a high-protein supplement such as soybean-oil meal mixed together with some of the cereal grains and wheat bran, to furnish the phosphorus, should not lack in minerals. However, it is well known that animals do sometimes suffer from an inadequate supply of minerals. This is brought about under several conditions, such as the following.

1. Lack of Minerals in the Soil. Some soils never did have sufficient minerals, whereas other soils have been depleted of their minerals by heavy and continuous cropping. Whatever the cause, crops grown on such soil give serious trouble to the dairyman, as the cattle fed crops produced on such soils may become affected by a lack of sufficient minerals.

2. Lack of Minerals in the Ration. Insufficient feed or rations low in mineral content may result in mineral deficiency, which shows up in the dairy herd. Cattle that subsist on a very low level of feed intake often do not obtain sufficient protein, total digestible nutrients, or minerals, and as a result become very unthrifty. Sometimes, however, the ration may seem adequate as far as protein and total digestible nutrients are concerned and still lack in mineral content. This is because the crops are grown on soil that lacks minerals. It will be necessary in that case either to fertilize the soil or to feed the animals additional minerals.

3. Lack of Vitamin D in the Ration. Even though the ration may contain sufficient protein, digestible nutrients, and minerals, a deficiency disease may nevertheless develop. The calcium and phosphorus of a ration cannot be properly assimilated unless vitamin D is present. If this vitamin is lacking in the ration for several months, stiffness in legs and joints, an arched back, and general unthriftiness may occur. This vitamin is found most abundantly in well-cured hay and is manufactured in the body when animals are exposed to the ultraviolet rays of the sun.

Minerals Needed by Dairy Cattle

Common Salt (NaCl). The sodium and chlorine are contained in common salt, and this should be supplied at all times. All herbivorous animals require a large amount of salt, but carnivorous animals do not require more than they obtain in their feed. Bunge [*] states that chlorine is the essential element supplied by salt. He states that the chlorine unites with the potassium that is found in large amounts in feeding stuffs and thus helps expel it from the body.

Symptoms of salt deficiency, with the exception of the craving of the animal in the early stages, are slow in appearing. After several months, however, milk flow may be lowered, the appetite may be impaired, and the animal may lose flesh. Ordinary feeds do not contain enough salt for the needs of cattle. Calves fed a liberal supply of milk do not require extra salt.

Calcium. Of all the natural feeds, legume roughages and pastures are the best sources of calcium. If the winter ration does not have any legume roughage and even when bleached-out legume hay is fed, there may be a deficiency of calcium in the ration. Cattle require more calcium than phosphorus, because the amount of calcium in the body and in the milk is much greater than the amount of phosphorus. However, a calcium deficiency in the ration is less likely than a phosphorus deficiency. This is because roughage makes up a large part of the ration of the dairy animal and most roughage is richer in calcium than in phosphorus. Only when poor roughages are fed or when the cows

[*] *J. Dairy Sci.*, 1:487.

are fed largely on grain and other concentrates is a deficiency in calcium likely. It is known that a cow can produce milk for some time, even for several months, without sufficient minerals in her feed, especially calcium or phosphorus. This is because she can draw on the reserve supply (the calcium and phosphorus in her bones). If she is required to draw on this reserve she should be given a chance at some time to replace it. This restoration can be made, especially when low mineral rations are fed, only when the cow is dry, or nearly so, and best when she is on good pasture. This emphasizes the importance of a dry period. Forbes * found that calcium metabolism of the milch cow, regardless of how she is fed, is characterized by a rapid loss of calcium from the body during the early part of the lactation, changing to retention late in the lactation; by continued retention during the dry period; and by the most rapid storage at the end of gestation. Although this is probably true under most conditions of feeding, Huffman † has shown that dairy cows on a heavy ration of good alfalfa hay are able to maintain a positive mineral balance even when they were producing as much as 70 pounds of milk per day.

PHOSPHORUS. Most roughages and grains are only fair to poor sources of phosphorus. If the roughages are grown on soils low in phosphorus they may not contain sufficient phosphorus and deficiencies may develop, especially if the animals are being fed largely upon roughages without some protein supplement. The cereal grains are richer in phosphorus than in calcium but contain only a moderate amount. However, most of the protein-rich by-products of plant origin are much higher in phosphorus than are the cereals and roughages. Wheat bran is especially rich in phosphorus, standard wheat middlings, cottonseed meal, and linseed meal are rich in phosphorus, and soybeans and soybean-oil meal are medium rich in phosphorus. When these feeds are fed in large amounts there will probably be no lack of phosphorus in the ration.

Symptoms of phosphorus deficiency in dairy animals are most likely to occur during growth and during heavy lactation. During growth, the symptoms are swollen, stiff, and aching joints; an arched back; beaded and deformed ribs, and failure to grow

* *J. Biol Chem*, 52:28.
† *J. Dairy Sci*, 13.432.

Fig 14 Results of mineral deficiency This cow was so stiff she could scarcely walk, her joints made a noise as she moved, and she showed the typical abnormal appetite (*Becker*)

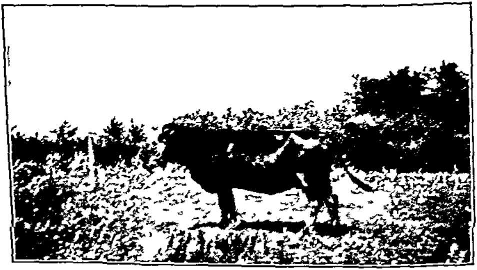

Fig 15 Results of feeding bone meal to cow shown in Fig 14 Note the difference in apparent stiffness of hind legs and appearance of thrift of the animal (*Becker*)

normally. This condition is called rickets. During heavy production the symptoms may not be so pronounced, since the animal will draw on her reserve supply for some weeks before she shows any outward sign. The cattle suffering from such a deficiency often have a depraved appetite and exhibit a craving for such things as bones, pieces of wood, and other foreign material. Internally, their bones lose part of their calcium and phosphorus, and the phosphorus content of the blood is lowered. This condition is called osteoporosis, or osteomalacia when it appears in mature animals.

CALCIUM-PHOSPHORUS RATIO. Not only should dairy animals be fed sufficient calcium and phosphorus, but a proper ratio should be maintained between the two minerals. If there is a great excess of one or the other of these minerals, bad effects may result even though both are being fed in sufficient amounts. Less vitamin D is required when the proper calcium-phosphorus ratio is maintained. A 1:1 or 2:1 ratio seems to be satisfactory to dairy animals, though if sufficient vitamin D is fed a wider ratio may be fed without harm, provided that there is an adequate supply of both minerals.

IODINE. In certain sections of the country where there is a lack of iodine in the feeds grown, calves at birth may have an enlargement of the thyroid gland, a trouble commonly called goiter, or "big neck." It is caused by a lack of iodine in the ration of the dam of the calf. Some calves are stillborn and others are weak when born and fail to survive. Many, however, live, but the swelling in the neck may remain until she matures. Some calves may have very thin coats of hair or be nearly hairless

COPPER AND IRON. Copper and iron are needed in the body for the formation of hemoglobin in the blood, and when they are deficient in the feed, an animal may suffer from nutritional anemia. Ordinarily, there is no lack of these elements in the ration of the dairy cow. However, in certain areas, notably in the sandy region of Florida,* the forage is so low in these elements that cattle do suffer from anemia. It is known also that calves fed on rations consisting of milk as an exclusive diet or with grain will suffer from anemia. When roughage is fed such trouble will be avoided.

* *Fla Exp Sta Bul* 231.

COBALT. If the soil is deficient in cobalt, ruminants fed on the feed produced on this soil may show a disease because of the lack of cobalt. Animals so affected will lose their appetite, become unthrifty and emaciated, and may exhibit depraved appetites. Young animals may fail to grow normally and have delayed sexual development.

Cobalt deficiency was first noted in New Zealand and Australia. It, however, has been found in various places in the United States, often called "Salt Sickness." The trouble has been reported in Florida, North Carolina, New York, New Hampshire, Massachusetts, Michigan, and Wisconsin, sometimes combined with a deficiency of copper and iron. Since the deficiency is found only in ruminants it is thought that it might be associated with the digestion in the paunch, perhaps in the growth of certain important bacteria.

MAGNESIUM. It is very seldom that the feed of the dairy animal does not contain sufficient magnesium. The feed of calves is sometimes deficient, causing a tetany of the animal. It is thought also that the lack of magnesium together with other mineral elements may be the cause of a trouble that sometimes appears in the early spring pasture and is known as "grass staggers" or "grass tetany." This disease often proves fatal.

OTHER TRACE MINERALS. The normal feed of the dairy cow, as far as is known, contains sufficient amounts of the other elements to satisfy the needs of the animal.

Supplying Minerals to the Dairy Animal

(a) Common Salt. One of the common ways of supplying the needed salt is to keep it in a box, to afford the animals easy and free access as they require it. Salt blocks may be used in the pasture but are not as satisfactory for milking cows as loose salt in covered boxes since too much time is required of the cow to get her needs. Milking cows on pasture at the Cornell Station* consumed 1.5 ounces of block salt per day, compared to 2.8 ounces of loose salt by similar cows. At the Virginia Station† 7 minutes were required for a cow to lick 1 ounce of salt

* *Cornell Farm Research* (July 1951)

† Unpublished data.

from a salt block. One of the common methods of adding salt is to put 1 to 1¼ pounds in each 100 pounds of grain mixture. When this is done, the cows should also be given free access to salt so that they may secure their requirements if the amount in the grain is not sufficient. Cows will not eat too much unless they have previously received an insufficient amount.

Salting at intervals of several days or weeks is not recommended. The actual amount of salt needed depends upon the size of the animal and the amount of milk she is producing. Babcock * concluded that dairy cows should be given about 0.75 ounce per day for each 1000 pounds of live weight, and about 0.6 ounce in addition for each 20 pounds of milk produced. Iodized salt is often used, especially in areas where goiter is a problem.

(*b*) **Calcium.** Calcium is best supplied by feeding good legume roughage. All the legumes are rich in calcium, but the cereal grains and their products and nonlegume roughages are, as a rule, low in calcium. When the feed of a cow is low in legumes, some calcium supplement should be fed. If a ration is deficient in calcium alone, then one should feed only calcium for supplement. Finely ground limestone (100 per cent of it should pass through a 40-mesh screen), marl, wood ashes, ground oyster or clam shells, and gypsum may all be used when calcium alone is needed. When phosphorus is also deficient, steamed bone meal of feeding grade can be fed. Steamed bone meal contains both calcium and phosphorus and is recommended when both are lacking.

The best way to feed bone meal, ground limestone, marl, wood ashes, etc., is to add it to the grain ration at the rate of 1 to 2 pounds for each 100 pounds of mixture. Sometimes both the ground limestone and the bone meal are added to the ration. These can also be fed like salt, or mixed with salt, by allowing free access to it. It can be put in open boxes, protected from the weather, or placed in small cups attached to the manger. Cows will seldom eat more than they need when fed in this way.

(*c*) **Phosphorus.** Phosphorus is best supplied by feeding some of the high-quality protein supplements, especially wheat bran, wheat middlings, cottonseed meal, and linseed-oil meal. Soy-

* *Twenty-second Annual Rept.*, Wisc. Exp. Sta.

bean-oil meal and the cereal grains and their products are medium in phosphorus, but the hays, silages, and straws and stovers are low in phosphorus However, if a good protein ration with sufficient protein to meet the needs of the animal is fed, there is usually no lack of phosphorus in the ration Because of the fact that all the common roughages, the feeds most commonly fed to dairy animals, are low in phosphorus, this element is more often lacking than calcium and most other minerals Several supplements for phosphorus exist, but one should be careful to choose a supplement that is not too high in its percentage of fluorine

Bone Meal Steamed bone meal specially prepared for livestock feeding *is one of the best forms of phosphorus to feed* It also contains calcium It has about 32 per cent calcium and 15 per cent phosphorus in *its composition* *It can be fed in the grain* ration at the rate of 1 to 2 pounds per 100 pounds of the feed

Spent Bone Black. Spent bone black, a by product in the use of bone meal in the clarifying and decolorizing of the syrup in the manufacture of sugar, is sometimes used for a phosphorus and calcium supplement when the price warrants its use It contains about two thirds as much calcium and phosphorus as does bone meal and is not quite so palatable

Dicalcium Phosphate *Dicalcium phosphate, made from rock* phosphate, is quite satisfactory as a phosphorus supplement, provided that it does not contain more than 0 3 per cent fluorine It contains about 18 per cent phosphorus

Effects of Too Much Fluorine Traces of fluorine are needed in order to develop high-quality teeth, but such amounts will usually be supplied in ordinary rations Rock phosphate however, contains as much as 3 to 4 per cent fluorine and is unsafe to use Fluorine is a poison when taken into the body in large amounts Since it is a cumulative poison ordinary rock phosphate, even when fed *in small amounts is unsafe to use* *Cattle* fed rock phosphate will develop badly decayed teeth, which will eventually lead to poor appetites, loss in weight, and decline in milk production

Defluorinated Rock Phosphate Rock phosphate or superphosphate is now being heated to a high temperature which drives off most of the fluorine, and it is then called defluorinated phosphate It should not contain over 0 3 per cent fluorine It can

be fed in the same way and in the same amount as was recommended for steamed bone meal, but care should be taken to see that not too much fluorine is fed.

(*d*) **Iodine.** In areas where iodine deficiency is a problem, if the cattle are fed iodinized salt instead of ordinary salt, there will usually be no trouble with goiter. The iodinized salt should contain at least 0.007 per cent iodine and the iodine should be put in by a process that will stabilize the iodine so that its strength will not be weakened. In areas where there is no deficiency, it is not necessary to add it to the ration. A farm mix of iodized salt may be made by adding $\frac{1}{6}$ ounce of potassium iodide to 100 pounds of common salt, mixing it first with a few pounds of salt and then mixing this with the remainder in order to get a thorough mixture.

(*e*) **Iron and Copper.** Only when there is a definite lack of iron and copper in the ration should they be fed. An excess of iron seems to interfere with the absorption of phosphorus by forming insoluble iron phosphates, and an excess of copper may cause poisoning of the animal. Ordinarily, there is no lack of these elements in the feeds of dairy animals, but in certain sandy areas the forage is so low in these elements that cattle suffer from anemia. Often, the deficiency is combined with a deficiency of cobalt. The trouble can be prevented by giving the cattle access to a mineral mixture consisting of 100 pounds of common salt, 25 pounds of red oxide of iron, 1 pound finely ground copper sulfate, and, when combined with a cobalt deficiency, 1 ounce of cobalt sulfate, cobalt chloride, or cobalt carbonate This should be thoroughly mixed so that the animal will not get too much of the copper or cobalt.

(*f*) **Cobalt.** In areas where cobalt deficiency occurs, so that animals become "salt sick," the trouble may be prevented by thoroughly mixing 0.5 to 1 0 ounce of cobalt sulfate, cobalt chloride, or cobalt carbonate with 100 pounds of salt and giving the animals free access to it. When iron and copper are lacking they should also be added as described above. If the animals are already badly affected with cobalt deficiency, it may be necessary to drench the animal in order to get the cobalt into her. A suitable treatment would be to make a stock solution of 1 ounce of cobalt sulfate in 1 gallon of water, and for mature animals give

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1 tablespoonful per day in a drench and for young calves 2 tea spoonfuls per day in their milk. This should be continued only until the animal can eat the salt. One should avoid feeding too much cobalt, although the exact amount that will cause trouble has not been definitely established

Mineral Mixtures Complex proprietary mineral mixtures are often found on the market containing other minerals than have been herewith recommended. Many of these have been tried out experimentally and have given no better results than simple mixtures containing the minerals that are known to be lacking A simple mineral mixture consisting of 2 parts of bone meal, 1 part of finely ground limestone, and 1 part salt will usually give good results If, however, the deficiency is for calcium alone, 2 parts of finely ground limestone, with 1 part of salt would be sufficient. If there is a phosphorus deficiency, bone meal or one of the other phosphorus-containing substances should be used instead of the limestone However, when the deficiency is not fully known, the first mixture mentioned should be fed. In using these mixtures they may be put into a box to which the cows have free access, or they may be added to the grain mixture at the rate of about 40 to 60 pounds per ton In areas where a de ficiency of iodine exists, iodinized salt should be used, in areas where other deficiencies are known to exist, the ration should be supplied with the minerals as previously advised If not needed, the feeding of trace minerals in a salt mixture will not be of any help and may be detrimental Experiment stations are recom mending the feeding of only those elements that are likely to be lacking.

VITAMINS

The feeding of vitamins to dairy animals plays an important part in their nutrition These organic compounds profoundly affect dairy farming by increasing the efficiency of production and by preventing nutritional diseases The vitamins in the ration are important not only for the nutrition of the cow herself but for the nutritiveness of the milk that she produces In most of the studies of feeds the needs of the animal are the only considera tion, but with vitamin feeding it is necessary to consider also its effect on the vitamin content of the milk produced The milk

should carry an adequate supply of the vitamins since it is used as human food.

There are at present at least 15 or 16 vitamins whose existence has been proven and their functions studied. Only two of these, however, must be furnished to the mature dairy animals in the feed. The cow seems to be able to synthesize many of them in her body. The two that must be furnished to the cow are vitamin A or its precursor, carotene, and vitamin D.

Vitamin A and Carotene. Carotene is the precursor of vitamin A. Plants do not have vitamin A in their composition. The animal can change the yellow colored carotene of the feed to the colorless vitamin A in her body. This is a simple chemical change, taking place, probably, in the intestinal wall,* and it results in the splitting of the carotene molecule into two molecules of vitamin A, thus

$$C_{40}H_{56} + 2H_2O \rightarrow 2C_{20}H_{30}O$$
$$\text{Carotene} + \text{Water} \rightarrow \text{Vitamin A}$$

Carotene is widely distributed in plants but is more abundant in those of green, yellow, or orange color. The feeds increase in their carotene content as the color intensifies. The dairy cow must be given carotene in her feed since she cannot synthesize vitamin A or carotene in her body, and it is necessary for life and well-being. The liver acts as the storehouse of carotene and also serves to regulate the amount of vitamin A to be transferred to other parts of the body. In milk is found both vitamin A and carotene. Since vitamin A is colorless, milk yellow in color contains both vitamin A and the unchanged yellow carotene.

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Probably the best source of carotene is good, green pasture.

* *Borden's Review of Nutrition Research*, 13:64 (1952).

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Probably the best source of carotene is good, green pasture.

* *Borden's Review of Nutrition Research*, 13.64 (1952).

Often, the milk from cows on pasture will contain more than twice as much vitamin A and carotene as when they are barn fed. However, even pasture, when it becomes dry and weathered, loses much of its carotene content and cannot be counted on as a good source of carotene.

In the field curing of hay or other dry roughages a considerable portion of the carotene is destroyed, especially if it is bleached either by the sun or rain. Hay cured with a green color is a good source of carotene. Much of the carotene may be lost during storage for a long period of time.

Corn silage varies considerably in its carotene content, depending upon its greenness when ensiled; if ensiled when very green, it may have as much carotene as well cured alfalfa hay. Hay-crop silages ensiled when the crop is green is a good source of this vitamin. Corn stover, straws and similar feed lacking in green color are extremely low in carotene.

The concentrates, with the exception of yellow corn meal and by-products made from it are practically free of carotene. Even yellow corn is not a good source of carotene, since it contains only about one-tenth to one-quarter as much carotene as does well cured alfalfa hay and the amount fed is so much less.

Cod liver oil and other fish liver oils are the richest source of vitamin A. These oils are often fed to dairy calves; cod liver oil however, is not suitable for dairy cows because of the depressing influence it has on the fat percentage of the cow's milk.

The requirements of carotene and vitamin A for dairy cattle is given in Table B in the appendix. The best way to supply the needed vitamin A is to furnish the cows an adequate supply of green pasture in the summer time and to feed them high quality, leafy, green roughage (hay or silage) during the winter months.

Vitamin D. Green forage, silages, and their by-products are low in vitamin D. In fact growing crops are entirely lacking in vitamin D. The sunlight or other lights that contain the ultraviolet rays have the power of changing the provitamin D, ergosterol and related compounds, into vitamin D. Small amounts of these provitamins are found in most of the common feeds, which when exposed to the sunshine, change into vitamin D. Hays cured away from the sun are usually low in this vitamin as are hay crop silages. Corn silage may have a moderate amount

Cattle exposed to the sun's rays usually will not be lacking in this vitamin, for the ultraviolet rays from the sun, acting upon these provitamins in their bodies, produce sufficient vitamin D for their needs. During the season of the year when cows are housed, or when there is little or no sunshine, cattle may be lacking in this vitamin, although this is seldom experienced. The feeding of activated, or irradiated plant sterol (300 to 400 International units per 100 pounds liveweight daily) is a sufficient protection against rickets for calves that are not in sunlight. It has never been proven experimentally that mature cows benefit from the addition of vitamin D in the ration, but it is often added to the dairy ration, especially during the winter months. One pound of irradiated yeast or other vitamin D supplement is added to 1 ton of the feed.

The feeding of 10 ounces per day of irradiated yeast to milking cows over a period of time will result in a milk that is quite rich in vitamin D. However, since it is rather expensive to add vitamin D in this way, this method of fortifying milk has given way to other less expensive methods.

Vitamin B Complex. Vitamin B complex is a term now applied to a group of vitamins that was formerly considered a single factor, vitamin B. There seem to be at least twelve or more of these vitamins, and perhaps others that have not been isolated as yet.

However, it is unlikely that these vitamins will be lacking in rations of dairy cows, for two reasons. (1) Green forage, such as pastures, are rich in these vitamins. Well-cured legume hay and silages are good sources of these vitamins. Good mixed hay also helps supply them. (2) The dairy cow, through the action of the organisms in her paunch, has the ability to synthesize these vitamins. An ample supply is therefore assured to the cow, even though the feed may be lacking in them.

A dairy cow will seldom have a deficiency in these important vitamins. No benefits have been obtained by feeding calves vitamin B supplements even before the normal rumen digestion starts, after which they can manufacture their own in the paunch. The milk that is fed to young calves will supply their needs.

Vitamin C (Ascorbic Acid). The lack of ascorbic acid in the ration of certain animals (man, monkey, and guinea pig) leads to a

disease known as scurvy With dairy cattle, however, such a disease is not known The cow probably has a requirement for the vitamin, but is able to synthesize sufficient amounts for her needs somewhere in her body The amount of vitamin C in the milk is not greatly affected by the amount that is in the feed consumed Experiments have shown that dairy cows may be fed large amounts of ascorbic acid in their rations or may be fed rations practically devoid of it, and, in both cases, the amount in their milk is normal

Green forage and sprouted seeds are rich in vitamin C, and the silages are good sources Dried roughages, grains, and their by-products are lacking in this vitamin Since vitamin C is easily oxidized it is almost useless to feed it to cows, because it would be oxidized in their paunch and they would receive little benefit from it

Experiments have failed to establish that the feeding or the hypodermic injection of a solution of ascorbic acid into the animal has any beneficial results in cases of sterility in either cows or bulls

Vitamin E Vitamin E is necessary for successful reproduction in certain species of animals, but with the dairy cow there seems to be no deficiency This may be (1) because the common feeds contain an ample supply of this vitamin, or (2) the animal is able to synthesize her own needs somewhere in her body, or (3) she does not need the vitamin for reproduction

Gullickson * fed dairy cattle on rations deficient in vitamin E They reproduced normally Several of the experimental animals died suddenly during the trials apparently from cardiac failure, probably as a result of vitamin E deficiency

Vitamin E is found in most of the common feeds fed to dairy cows It is abundant in the germ of the cereal grains and other seeds, in green forage, and in high-quality hays Different forms of this vitamin have been isolated and these organic compounds are called tocopherols

Minerals and Vitamins Easily Supplied. From the foregoing discussion, it can easily be seen that dairy cows on a good, carefully balanced ration, selected and fed according to ordinary

* *J Dairy Sci*, 32 495

The Development of Feeding Standards

A feeding standard is a tabulation of the feed requirements for maintenance and milk production, or for growth and reproduction In the past, it has been based chiefly upon the requirements for digestible protein and total digestible nutrients or energy Considerable information now exists as to the requirements of dairy animals for calcium, phosphorus, and carotene The minimum requirements of certain other minerals and vitamins are also known, so that the scope of feeding standards is widening

The three general types of feeding standards are (1) the comparative type, which was based on simple feeding trials in which one feed is compared with another, (2) the digestible nutrient type, in which the requirements are based upon the digestible composition of the feeds, and (3) the production value type, in which the requirements are based upon the energy requirements of the animal

COMPARATIVE TYPE

Thaer's Work The German scientist Thaer in the year 1810 suggested a method of comparing the different feeds He used meadow hay as a unit and based the value of the rest of the feeding stuffs on its value He found, for instance, that only 91 pounds of alfalfa hay were necessary to equal 100 pounds of meadow hay in feeding value, and that 200 pounds of potatoes were required to replace 100 pounds of meadow hay He never formulated a definite standard but simply gave a comparison of the feeding stuffs A system very similar to this is now used extensively in the Scandinavian countries

Scandinavian Feeding System. The Scandinavian feeding standard is more valuable than that of Thaer in that it is the result of observations on thousands of cows, extending over a great number of years The quantity of milk was also taken into consideration For some years * a number of dairy farms in Denmark, Sweden, and parts of Norway were under the direct observation of the respective governments Complete records were kept of the feed consumed and of the quantity of milk produced, and in 1884 Professor Fjord formulated the Scandinavian feeding standard The basis of this standard is the feed unit One pound of the common grains, such as corn, barley, wheat, etc, is given a value of 1 unit, and the value of all other feeds is based upon these, some being higher and some lower as the case might be According to the Scandinavian standard, 1 feed unit is required for each 150 pounds of body weight, and 1 additional unit for every 3 pounds of milk produced

The feed unit values are not entirely accurate, since feeds rich in protein are often given a higher value than those low in protein but containing an equal amount of net energy For example, gluten feed has a feed-unit value of 0 88 (0 88 pound equals 1 feed unit) This is lower than that of corn, which is 0 97, but according to the table showing the net energy value, corn contains more net energy than does gluten feed

The greatest value of this system is its simplicity The feed-unit value of the common feeds can be remembered and after a little practice a practical ration can be figured without referring to tables

Since the condition and the feeds in the United States are so different from those in the Scandinavian countries, this system has never been used widely here

DIGESTIBLE NUTRIENT SYSTEM

Grouven's Feeding Standard In 1859,† about 50 years after Thaer published his comparisons, Grouven, another German experimenter, proposed a feeding standard based upon the crude protein, carbohydrates, and fats contained in the feeds His

* *Wisc Exp Sta Circ* 37

† *Cornell Exp Sta Bul* 323

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The feed-unit values are not entirely accurate, since feeds rich in protein are often given a higher value than those low in protein but containing an equal amount of net energy. For example, gluten feed has a feed-unit value of 0.88 (0.88 pound equals 1 feed unit). This is lower than that of corn, which is 0.97, but according to the table showing the net energy value, corn contains more net energy than does gluten feed.

The greatest value of this system is its simplicity. The feed-unit value of the common feeds can be remembered and after a little practice a practical ration can be figured without referring to tables.

Since the condition and the feeds in the United States are so different from those in the Scandinavian countries, this system has never been used widely here.

DIGESTIBLE-NUTRIENT SYSTEM

Grouven's Feeding Standard. In 1859,† about 50 years after Thaer published his comparisons, Grouven, another German experimenter, proposed a feeding standard based upon the crude protein, carbohydrates, and fats contained in the feeds. His

* *Wisc. Exp. Sta. Circ.* 37.

† *Cornell Exp. Sta. Bul.* 323.

standard required that a cow weighing 1000 pounds be fed 28 7 pounds of dry matter containing 2 76 pounds of crude protein, 0 86 pound of crude fat, and 14 55 pounds of crude carbohydrates

Soon after this standard was proposed, Henneberg and Stoh mann carried on digestion trials and found that the total nutrients contained in a feed did not form an accurate guide to its value The proportions of the digestible parts varied with the different feeds, hence, digestible nutrients would be more valuable

Wolff's Feeding Standard Dr Emil von Wolff made similar studies, and in the year 1864 proposed a standard based upon the digestible protein, digestible carbohydrates, and digestible fat His standard for dairy cows weighing 1000 pounds is as follows dry matter, 24 5 pounds containing 2 5 pounds of digestible protein, 12 5 pounds of digestible carbohydrates, and 0 4 pound of digestible fat This has a nutritive ratio of 1 to 5 4 The nutritive ratio is the proportion of protein to carbohydrates plus 2¼ times the fat This standard, although a great im provement over the others, was deficient in that it did not take into consideration the quantity and quality of the milk produced

Wolff Lehmann Feeding Standard The Wolff standard was used until 1896, when it was modified by Dr C Lehmann of Berlin after which it was called the Wolff Lehmann standard Lehmann took into account the quantity of milk This was an improvement over the Wolff standard, although Lehmann failed to take into account the quality of the milk This standard was used for a great many years, and at the present time various modifications of it are employed extensively in the United States

Haecker's Feeding Standard Haecker, of the University of Minnesota, added two refinements to the standards of his time * He was the first to separate the requirements for maintenance from the requirements for milk production, and he also took into consideration not only the quantity of milk but also its quality

With this system the needs of a cow of any size, producing any quantity or quality of milk, can be easily computed Haecker expressed the value of the feeds under three heads—digestible crude protein, carbohydrates, and fat Later, however, they

* *Minn Exp Sta Bul* 130

were grouped under two heads: * namely, digestible crude protein and total digestible nutrients.

Savage Feeding Standard. Savage, of the Cornell Experiment Station,† after many trials, came to the conclusion that the Haecker standard was too low, especially in protein. He maintained that the nutritive ratio should not be wider than 1 to 6. His standard, therefore, increased the protein requirement above that of the Haecker standard by about 20 per cent. He also combined digestible protein, digestible crude fiber, digestible nitrogen-free extract, and digestible fat multiplied by 2¼ into what is called total digestible nutrients. This was done to simplify the computation of a ration. Other standards, including the Haecker standard, are now expressed in this manner.

Morrison Standard. Professor F. B. Morrison, the author of *Feeds and Feeding*, endeavored to combine in one set of standards what seemed in his judgment to be the best guides available in the computation of rations for various classes of livestock. These were first published in 1915, the fifteenth edition of *Feeds and Feeding*. Extensive changes were made in 1936, in the twentieth edition, and many more changes were made in 1948 and published in the twenty-first edition of *Feeds and Feeding*. These changes were made because of much additional information which has been gained concerning the nutrient needs of dairy cattle. This standard is given in Table *B* in the appendix. The standard is now expressed in terms of digestible protein and total digestible nutrients, as in the earlier standard. However, figures are given for the net energy requirements, so that if one desires he can compute rations, using net energy and disregarding the total digestible nutrient figures. In this standard, recommended allowances are also given for calcium, phosphorus, and carotene. Also, the digestible protein, total digestible nutrients, and net energy are given a range. This has been done because it was felt that the economic conditions should determine whether it is better to use the lower or the higher figure. For example, if high-protein feeds are not unduly high in price, it is best to use the higher recommendation, but if proteins are expensive, it would be better to use the lower recommendations. The same

* *Minn. Exp Sta. Bul* 218.
† *Cornell Exp. Sta. Bul.* 323.

could be said about total digestible nutrients Furthermore, it should be understood that the nutrients recommended are only guides, that the same kind of feed may differ greatly in analysis and feeding value, and that animals themselves differ somewhat in their ability to utilize feeds For these reasons, the results should be satisfactory if the ration falls within the limits set.

National Research Council Standard. A recommended nutrient allowance for dairy cattle was prepared by a subcommittee of the committee of animal nutrition of the National Research Council It was published in 1945 and revised in 1950 This was the first attempt in the history of animal nutrition to develop nutrient standards for dairy cattle by a committee of nutritionists who had made a specialty of dairy cattle nutrition This standard is given in *Table C* in the appendix.

It will be seen that this standard is stated in terms of digestible protein and total digestible nutrients and also includes the recommended requirements for calcium phosphorus, and carotene, as well as vitamin D for growing animals It also gives the requirements for growth and for the last 6 to 12 weeks of pregnancy Maintenance requirements of breeding bulls are also included The requirements are quite similar to those of the Morrison standard

PRODUCTION VALUE TYPE

Kellner Feeding Standard Kellner, a German investigator, published in 1907 a feeding standard * based upon starch as the unit of measure He also took into account not only the digestibility of the feeds, as calculated from the amount lost in the feces, but also the entire loss from the body and the energy expended in digesting and passing the food through the body The amount remaining is what the animal has left to use in a productive way Kellner's standard is thus more complete than the previous ones

Armsby Feeding Standard. By the use of the respiration apparatus Kellner and Zuntz were able to determine how much of the energy of the feed was required for mastication, digestion, and assimilation Armsby went a step further by using the respi

* *The Scientific Feeding of Farm Animals* Kellner

ration calorimeter. He determined not only the energy required for mastication, digestion, and assimilation of the food, but also the amounts of heat and gases given off by the body. By means of his apparatus he was able to calculate the true net energy available in the various feeding stuffs. Table X shows what becomes

TABLE X

NET ENERGY FROM 100 POUNDS OF CORN MEAL, TIMOTHY HAY, AND WHEAT STRAW

	Gross Energy, therms	Energy Lost in			Available Energy Remaining, therms	Energy Lost in Work of Digestion, therms	Net Energy Remaining, therms
		Feces, therms	Methane, therms	Urine, therms			
100 lb corn meal	180.3	21.2	15.9	8.1	135 1	52.2	82.9
100 lb. timothy hay	181.2	86.2	13.6	7.1	74.3	31.3	43.0
100 lb. wheat straw	184.6	107.5	15.3	4.4	57.4	47.3	10.1
Expressed in Percentage							
Corn meal	100	12	9	4	75	29	46
Timothy hay	100	48	7	4	41	17	24
Wheat straw	100	59	8	2	31	26	5

of the digestible nutrients of corn meal, timothy hay, and wheat straw when fed to dairy cattle.

He found that the amount of energy lost in the gases and in the labor of mastication, digestion, and assimilation sometimes exceeds the amount lost in the feces and urine, the two latter being the only losses considered in the other standards. It is not the amount of digestible parts alone that is essential, but it is the net value available for maintenance and production. The Armsby standard is based, then, upon the actual work that the feed will perform.

Armsby based his ration on the digestible true protein and

therms of net energy The digestible true protein differs from the digestible crude protein in that true protein does not include free amino acids and amides, but as has already been noted it is now agreed that the digestible crude protein is a better measure of the protein value of a feed than is the true protein The net energy is based upon the calory as the unit, but in order to simplify the method Armsby suggested the name "therm," to apply to 1000 large calories

A definite amount of digestible crude protein and net energy is required for the maintenance of animals of different sizes, and an additional definite amount is required for milk of different quantities and qualities The amount of protein and net energy required for maintenance is based upon the body surface of the animal This was first used by Armsby but is now used in all the later standards

The immense amount of work necessary to determine the net energy value of any one feed made it impossible to secure data on a great many feeds For this reason the actual net energy values of only a few have been determined Most of them were computed from Kellner's data on the starch values It has also been found that even those that have actually been run should be considered merely as averages This is true because different samples of feeds will vary considerably These results also, were secured with steers only, other classes of livestock may vary from these averages

The Armsby standard has not been extensively used in the United States partly because the figures were not too accurate, and also because feeders seemed to understand digestible nutrients better than net energy as applied to feeds

However, for those that wish to use the net energy method the latest Morrison Standard includes the requirements for net energy as well as for total digestible nutrients, and net energy values for feeds are given in Table *A* in the appendix

LIMITATIONS OF FEEDING STANDARDS

A standard should be looked upon as a guide and cannot be used at all times It must be departed from sometimes to suit

the individuality of different animals, and at other times to obtain the most economical results.

Many other factors, as brought out in the previous lecture, are not taken into account in balancing rations. However, as our knowledge of feeds and the way they are used in the body has increased, many of the former uncertainties have disappeared. For example, the concern about incomplete proteins is no longer so pressing, because it is known that the bacteria and other organisms in the rumen build up complete proteins in their bodies and supply the cow with the needed amino acids. Also, there is at least a guide in the later standards as to the requirements for calcium and phosphorus and for carotene. Also, some knowledge has been gained regarding the requirements of a few of the other minerals and vitamins. These recommended requirements are tentative but at least there is some knowledge upon which to build.

Even now, however, many factors other than the nutritive requirements remain that should be taken into consideration when balancing a ration, such as palatability, succulence, bulk, and physiological effect upon the cow. In other words, a ration may meet the requirements of a standard as far as feed nutrients are concerned but may be very undesirable from a physiological or economical standpoint.

Another difficulty with feeding standards is that they are too difficult for general use. Farmers do not take the time necessary to study them sufficiently. However, herdsmen and other persons interested in dairying should and do become acquainted with their use.

Feeding standards, as a rule, are quite accurate, and can be used advantageously in showing the deficiencies of a ration that is being fed. It should be understood, however, that feeding standards, as well as the tables of nutrients, are but averages and will not apply to all feeds or to all conditions.

REFERENCES FOR FURTHER STUDY

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5 Savage, A Study of Feeding Standards for Milk Production, *Cornell Exp Sta Bul* 323 (1912).
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10

Balancing Rations

BALANCED RATIONS

A balanced ration is the feed or combination of feeds that will supply the daily feed requirements of an animal It is essential that the student in dairying and others interested in the feeding of dairy animals understand how rations are balanced The discussion of the method of balancing rations shall be limited to the Morrison standard, which is quite universally used in this country

Balancing Rations for the Individual Cow

The dairy cow requires feed for the following purposes (1) for the maintenance of the body (2) for the production of milk (3) for growth when they are immature, (4) for the growth and development of the fetus, and (5) for gain in weight when they are too thin With the dairy cow, the two main considerations are maintenance and milk production During the last 6 to 12 weeks before freshening cows are usually fed extra feed, partly for growth if the animal is immature, and partly for growth of the fetus, as most of its growth takes place at that time, but mostly for gain in weight since the animal should be in good flesh at the start of her lactation The requirements of individual cows differ since the nutrients required for maintenance vary with the size of the animal and the requirement for milk production varies with the amount and richness of the milk produced

PROBLEM

Calculate a balanced ration for a cow weighing 1000 pounds and giving 25 pounds of 4 per cent milk. The following feeds are available

Roughages	*Concentrates*
Clover and timothy hay	Wheat bran
Corn silage	Corn gluten feed
	Cottonseed meal
	Ground corn

By referring to Table *B* in the appendix, it may be seen that the maintenance requirement for a cow weighing 1000 pounds is 0 65 pound of digestible protein and 7 9 pounds of total digestible nutrients It will be seen also that for each pound of 4 per cent milk the cow requires 0 049 pound of digestible protein and 0 32 pound of total digestible nutrients in addition The total requirements, then, for the particular cow in the problem would be as follows

	Digestible Protein, pounds	Total Digestible Nutrients, pounds
Maintenance of a 1000 pound cow	0 65	7 9
For production of 25 pounds of 4 per cent milk	1 22	8 0
Total daily requirements	1 87	15 9

The problem now is to apportion the feeds so that they will supply these requirements, regard being paid to the characteristics of the different feeds It will be necessary, therefore, to furnish this cow the feeds that will contain 1.87 pounds of digestible protein and 15 9 pounds of total digestible nutrients each day As previously noted, a cow will usually consume about 1 pound of hay and 3 pounds of corn silage for each 100 pounds of her weight. For this cow, then, 10 pounds of clover and timothy hay and 30 pounds of silage may be fed. For feeding grain, a practical rule is to feed 1 pound of grain for each 3½ pounds of average milk that is being produced. This

should also provide an approximation of how much grain should be fed, which, in this example, would be between 7 and 8 pounds. The amounts of digestible protein and total digestible nutrients in the feeds can be ascertained from Table A in the appendix.

For a trial ration we shall use the feeds in the following proportions.

FIRST TRIAL RATION

Daily Ration	Digestible Protein, pounds	Total Digestible Nutrients, pounds
Roughage		
30 pounds of corn silage	0.36	5.43
10 pounds of clover and timothy hay	0.48	5.12
Concentrates		
2.5 pounds of ground corn	0.16	2.00
1 pound of corn-gluten feed	0.22	0.76
1.5 pounds of wheat bran	0.21	1.01
1.5 pounds of cottonseed meal	0.49	1.06
Total in ration	1.92	15.38
Daily requirements	1.87	15.90
Difference	+0.05	−0.52

This trial ration contains a slight excess of digestible protein but is deficient by 0.52 pound in total digestible nutrients. In the second trial, therefore, we shall add 1.2 pounds of ground corn and take out 0.5 pound of cottonseed meal.

SECOND TRIAL RATION

Daily Ration	Digestible Protein, pounds	Total Digestible Nutrients, pounds
First trial ration contains	1.92	15.38
Add 1.2 pounds ground corn	+0.08	+0.96
Deduct 0.5 pound cottonseed meal	−0.16	−0.35
Total in ration	1.84	15.99
Daily requirements	1.87	15.90
Difference	−0.03	+0.09

This ration is now very close to the requirements of the Morrison standard, and is as follows

Roughage	*Concentrates*
30 pounds corn silage	3.7 pounds ground corn
10 pounds clover & timothy hay	1 pound corn gluten feed
	1.5 pounds wheat bran
	1 pound cottonseed meal

Since 7.2 pounds of the concentrate mixture were needed to meet the requirements the ratio was about 1 pound of concentrates to 3½ pounds of milk.

NET ENERGY METHOD

Feeds that are high in net energy are also usually high in total digestible nutrients For example, corn contains approximately the same number of pounds of total digestible nutrients as it does therms of net energy, but wheat straw, a very low energy feed, contains more than 3½ times as many pounds of total digestible nutrients as it does therms of net energy

Morrison's feeding standards include the requirements for net energy The same problem may be used to illustrate the balancing of a ration when using digestible protein and net energy as the basis By this method the requirements would be as follows

	Digestible Protein, pounds	Net Energy, therms
Maintenance of a 1000 pound cow	0.65	6.3
For producing 25 pounds of 4 per cent milk	1.22	7.5
Total daily requirements	1.87	13.8

If the same feeds in the same amounts are used as in the former problem the ration will supply 0.26 therm more net energy than is required, but this is close enough for all practical purposes

	Digestible Protein, pounds	Net Energy, therms
30 pounds corn silage	0.36	4.56
10 pounds clover and timothy hay	0.48	4.10
3.7 pounds ground corn	0.24	2.96
1 pound corn-gluten feed	0.22	0.72
1.5 pounds wheat bran	0.21	1.01
1 pound cottonseed meal	0.33	0.71
Total in ration	1.84	14.06
Daily requirements	1.87	13.8
Difference	−0.03	+0.26

Checking on Calcium, Phosphorus, and Carotene. When there is any doubt as to a lack of calcium, phosphorus, or carotene in the ration, it is a good plan to check as illustrated below. In Table *B* in the appendix the requirements are given. Using the same problem as before, the cow's requirements and the amounts furnished in the feeds would be as follows.

	Calcium, pound	Phosphorus, pound	Carotene, milli-grams
Maintenance of a 1000-pound cow	0.022	0.0220	60
For production of 25 pounds of 4 per cent milk	0.055	0.0425	..
Total daily requirements	0.077	0.0645	60

The ration would contain:

	Calcium, pound	Phosphorus, pound	Carotene, milli-grams
30 pounds corn silage	0.0300	0.0180	192
10 pounds clover and timothy hay	0.0680	0.0200	70
3.7 pounds ground corn	0.0007	0.0100	8.14
1 pound corn-gluten feed	0.0048	0.0082	6.10
1.5 pounds wheat bran	0.0021	0.0194	0.12
1 pound cottonseed meal	0.0020	0.0122	0.09
Total in ration	0.1076	0.0878	276.45
Daily requirements	0.077	0.0645	60.00
Difference	+0.0306	+0.0233	+216.45

Sufficient calcium, phosphorus, and carotene are available, as would be expected when corn silage and part-legume hay are included. However, the amounts of calcium and phosphorus are not much over the requirements as set forth in the standard.

If timothy hay were to be substituted for the clover and timothy hay in this ration, there would, of course, be a lack of protein, but there would also be a lack of calcium as shown in the following tabulation:

	Calcium, pound	Phosphorus, pound	Carotene, milligrams
30 pounds corn silage	0.0300	0.0180	192
10 pounds timothy hay	0.0230	0.0200	53
3.7 pounds ground corn	0.0007	0.0100	8.14
1 pound corn gluten feed	0.0048	0.0082	6.10
1.5 pounds wheat bran	0.0021	0.0194	0.12
1 pound cottonseed meal	0.0020	0.0122	0.09
Total in ration	0.0626	0.0878	259.45
Daily requirements	0.0770	0.0645	60.00
Difference	−0.0144	+0.0233	+199.45

This illustrates the necessity of being sure that there is a sufficiency of these elements in the rations that are being fed.

Balancing Rations for the Herd

The method of balancing rations as already given is adapted to individual cows. When it comes to feeding a herd, it is not practical to compute a ration for each individual animal, as this would require too much time and effort. The method described can be used, however, if the average cow in the herd is taken as the basis for the calculation. Thus, the average weight of the cows and their average milk production and butterfat test serve as the basis for calculating a ration in the same manner. Such a ration, when fed according to specific rules based upon the production of the animals, should give good results. Another method of calculating a ration for a herd is to balance the protein of the grain mixture with the kind of roughage that is to be fed and to consider that sufficient total nutrients will be supplied. This

method, though not entirely accurate, does have the advantage of being easy to figure and should give satisfactory results.

Balancing Rations According to Average Cow in the Herd

When balancing rations according to the average cow in the herd it is necessary to know approximately the average weight of the cows in the herd and their average production and butterfat test. All dairymen should make a practice of weighing their milk, and from this they can figure their average production. When the test of butterfat is not known the following will be an aid in making an estimate.

	Per Cent
Herd of all purebred or high-grade Jerseys or Guernseys	5.0
Mixed herd with some Guernseys and Jerseys	4.5
Herd of Ayrshires, Brown Swiss, or mixed breeds	4.0
Herd of all Holsteins	3.5

If the weights of the cows are not known the following table will help make an estimate.

	Pounds
Herd of Jerseys	800–1000
Herd of Guernseys, Ayrshires, or mixed breeds	1000–1200
Herd of Brown Swiss	1200–1400
Herd of Holsteins	1200–1500

As an example of this method, assume a herd of mixed breeds giving on the average 24 pounds of milk, which is to be fed corn silage, mixed clover and timothy hay for roughage, and a mixture of ground corn, oats, wheat bran, and cottonseed meal for concentrates.

	Digestible Protein, pounds	Total Digestible Nutrients, pounds
Maintenance, 1100 pounds	0.71	8.60
Milk, 24 pounds, 4 per cent fat	1.18	7.68
Total daily requirements	1.89	16.28

According to the standard the average animal in this herd should be fed so that she will receive 1 89 pounds of digestible protein and 16 28 pounds of total digestible nutrients per day

The next step is to find a ration that supplies the nutrients as needed. As has already been noted when hay and silage are both fed a cow will consume approximately 3 pounds of silage and 1 pound of hay for each 100 pounds of live weight The rule of feeding 1 pound of concentrate to each 3½ pounds of milk produced will be used in this trial

	Digestible Protein pounds	Total Digestible Nutrients pounds
33 pounds corn silage	0 40	5 97
11 pounds mixed hay	0 53	5 63
2 pounds ground corn	0 13	1 60
2 pounds wheat bran	0 27	1 34
2 pounds ground oats	0 19	1 40
1 pound cottonseed	0 33	71
Total in ration	1 85	16 65
Daily requirements	1 89	16 28

This ration is almost right in digestible protein and slightly high in total digestible nutrients but is close enough for practical purposes

The concentrate part of this ration should then be mixed in the proportion as given above namely 2 parts ground corn 2 parts wheat bran 2 parts ground oats and 1 part of cottonseed meal and fed to the different cows in the herd in proportion to the amount of milk that they are giving as shown in Table XIII Chapter 11 The cows should be fed all the roughage that they will clean up

Determining Per Cent of Protein Necessary in the Concentrate Mixture The following method will balance the ration for the average cow in the herd and also indicate the per cent of digestible protein that should be in the grain mixture The following calculation is made using the same average cow weighing 1100 pounds and producing 24 pounds of 4 per cent milk

	Digestible Protein, pounds	Total Digestible Nutrients, pounds
Total requirements	1.89	16.28
Supplied by hay and silage	0.93	11.60
To be supplied by grain mixture	0.96	4.68

If it is assumed that the grain mixture contains 70 per cent total digestible nutrients, divide 4.68 by 0.70 and it will be found that 6.7 pounds of a grain mixture are needed. Since 0.96 pound of digestible protein is needed to be supplied by the grain mixture, divide 0.96 by 6.7 to find the per cent of digestible protein that should be in the grain ration, which, in this case, is 14.3 per cent.

Balancing Rations by the Protein Method

For general farm use, a simple method of balancing a ration for a herd is required, and even the one just described may sometimes prove too elaborate to be practical. Since there is seldom a deficiency in carbohydrates and fats when the animals have all the roughage they can eat, a roughly balanced ration may be obtained by balancing the protein of the grain mixture to go with the kind of roughage used and by disregarding the carbohydrates and fats.

The roughages can be divided into three groups as follows.

1. Low-Protein Group. Timothy hay, corn stover, straw, corn silage, or any other nonlegume. Percentage of digestible protein required in the grain mixture is 16 to 20, or 20 to 24 per cent of total protein.

2. Medium-Protein Group. Mixed hay, legume hay and corn silage, or other roughage with at least half of the roughage composed of legumes. Percentage of digestible protein required in the grain mixture is 13 to 16, or 16 to 20 per cent of total protein.

3. High-Protein Group. Clover hay, alfalfa hay, soybean hay, hay-crop silage, or any of the legume roughages. Percentage of digestible protein required in the grain mixture is 10 to 13, or 12 to 16 per cent of total protein.

Making up a Grain Mixture for the Herd. As an example of this method of making up a ration for a dairy herd, assume that alfalfa hay and corn silage are available for roughage, which together are in the medium protein group, and that ground corn, ground oats, wheat bran, and cottonseed meal are available as concentrates By referring to Table A in the Appendix, the following figures for protein are obtained

100 pounds of ground corn contain	6 6 pounds of digestible crude protein
100 pounds of wheat bran contain	13 7 pounds of digestible crude protein
100 pounds of ground oats contain	9 4 pounds of digestible crude protein
100 pounds of cottonseed meal contain	32 8 pounds of digestible crude protein
Then	
400 pounds of the mixture contain	62.5 pounds of digestible crude protein

62 5 ÷ 400 = 0 156 or 15 6 per cent of digestible crude protein

By referring to the groups of roughages, it will be noted that, when the roughage is in the medium protein group, the digestible protein in the grain mixture should be from 13 to 16 per cent This ration then, should fulfill the requirements, provided, of course, that it meets the needs of the animals as to bulk, variety, palatability, physiological effect, mineral content, etc

Now, assume that instead of alfalfa and silage for roughage, timothy hay and corn stover, which are in the low protein group, are fed, and that the same concentrates as before are available It would be necessary to add more of the high protein feeds as follows

400 pounds of the mixture contain	62.5 pounds of digestible crude protein
100 pounds of cottonseed meal contain	32 8 pounds of digestible crude protein
500 pounds of the new mixture contain	95 3 pounds of digestible crude protein

95 3 ÷ 500 = 0 191, or 19 1 per cent of digestible crude protein

By referring to the groups of roughages, it will be noted that when the roughage is in the low protein group the digestible protein in the grain mixture should be from 16 to 20 per cent This ration fulfills these requirements and therefore should be satis factory

Now, suppose that the roughage consists of alfalfa hay alone, which is in the high protein roughage group, and that the same concentrates are available It would be necessary to add a low

protein concentrate, such as ground corn, to the first ration, as follows

400 pounds of the mixture contain	62 5 pounds of digestible crude protein
200 pounds of ground corn contain	13 2 pounds of digestible crude protein
600 pounds of the new mixture contain	75 7 pounds of digestible crude protein

75 7 — 600 = 0 126, or 12 6 per cent of digestible crude protein

The grain mixture to supplement the high-protein roughages should be between 10 and 13 per cent, and hence the foregoing ration would fulfill the requirements, yet, if desirable for any reason, the protein content of the ration could be still lower.

It is comparatively easy to balance a grain mixture in this way for any kind of roughage If the roughage is low grade, use a higher protein percentage in the grain mixture, and vice versa It is important, however, to keep in mind the characteristics of the feeds when making up the grain ration and to feed the ration according to the production of the individual cows in the herd

When the roughages are low grade it is also necessary to feed more of the grain mixture, since the cows will not consume so much poor-quality as better-quality roughages

Calculating a Feed Mixture. The commercial feed mixers attach a guaranteed analyses of the feed that is to be sold, in terms of the minimum percentage of crude protein, nitrogen free extract, and crude fat, and the maximum percentage of crude fiber The feeds are divided into classes in respect to protein content Usually, feeds are manufactured and sold containing 16 per cent, 20 per cent, 24 per cent, and 32 per cent crude protein The amount of digestible protein is approximately 80 per cent of the amount of total protein when high-quality feeds are used The 32 per cent mixture is used largely for mixing with homegrown feeds The rest of the analysis varies, but for a good concentrate ration the following characteristics are recommended that the crude fat be not under 3 per cent, and that the crude fiber should usually not be more than 10 per cent It is also desirable that the total digestible nutrients should be close to 70 per cent Besides these, all the characteristics of a good grain ration, such as have already been outlined, should be included Usually, salt and minerals are added, as has been recommended

The ration is usually figured on a ton basis and the weight of the salt and minerals are included. To mix a 16 per cent protein ration where corn meal, ground oats, wheat bran, and soybean-oil meal are available, the following method is followed.

Amt. of Ingredient, pounds	Name of Ingredient	Crude Protein, pounds	Dig. Protein, pounds	Crude Fat, pounds	Crude Fiber, pounds	Total Digestible Nutrients, pounds
1000	Corn meal	86.0	66.0	39.0	20.0	801.0
300	Wheat bran	50.7	41.1	13.8	28.8	201.6
300	Ground oats	36.0	28.2	13.8	33.0	210.3
350	Soybean-oil meal	155.0	130.2	18.5	20.0	274.4
20	Salt	......	......	.....	......	....
30	Bone meal	......	......	.....	......	....
2000	Mixture	327.7	265.5	85.1	101.8	1487.3
100	Mixture	16.38	13.27	4.25	5.09	74.36

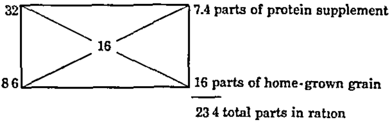
This ration would then be a 16 per cent protein mixture and would meet the requirements for all others of the constituents. It should make a good ration to feed to dairy cows. It should be fed according to the amounts that are given in Table XIII, Chapter 11.

Mixing Homegrown Feeds with 32 Per Cent Protein Rations. Many dairymen purchase 32 per cent protein rations and mix them with their homegrown grains to adjust the protein content to meet their roughage. An easy way to find out how much of each ingredient to use is by the use of the Pearson's Square. To use this method, the following rules should be observed. Make a square and (1) place the percentage of protein that is desired in the center of this square; (2) place the percentage of protein in the protein supplement at the upper left-hand corner of the square; (3) place the percentage of protein in the homegrown grain or grains in the lower left-hand corner of the square; and (4) take the difference between the figure in the center and each of the figures in the left-hand corners and place the results in the diagonal right-hand corners. The figure at the upper right-hand corner will be the number of parts of the protein supplement

needed, and the figure at the lower right corner will be the number of parts of the homegrown grains needed.

For example, how much homegrown ground corn (8.6 per cent protein) must be mixed with a 32 per cent concentrate mix to make a ton of a 16 per cent protein mixture?

To use the Pearson's square method, construct a square and put in the center the per cent of protein desired, which here is 16. On the upper left-hand corner place the percentage of protein in the protein supplement, which here is 32; and on the lower left-hand corner the percentage of protein in the grain to be used, which here is 8.6. Then subtract along the diagonal lines as illustrated.



In order to calculate the number of pounds of each ingredient needed to make a ton of feed containing 16 per cent protein, divide 2000 by 23.4, which gives the number of pounds in each part. Then, multiply the number of pounds by 7.4 and 16 to find the number of pounds of each of the two ingredients as follows:

$$\frac{2000}{23.4} = 85.47 \text{ pounds in one part}$$

then,

7.4 parts $\times$ 85.47 = 632.5 pounds of 32 per cent supplement
16 parts $\times$ 85.47 = 1367.5 pounds of ground corn

Here, 632.5 pounds of the 32 per cent protein supplement will be required to mix with 1367.5 pounds of ground corn to make a ton of a 16 per cent protein mixture.

If it is borne in mind that after subtracting diagonally the parts that are to be used are obtained, this system will lend itself to many different types of problems.

For example, in the illustration given above, a dairyman may have a specific amount, let us say, 1000 pounds of the 32 per cent mixture, which he wishes to mix with corn meal to make a 16 per cent protein mixture, and he wishes to know how much corn to use Of course, here the 7 4 parts would equal the 1000 pounds of 32 per cent concentrates and 1 part would be 1000/7 4 or 135 1 (value of 1 part) and 16 parts would be 16 times 135 1, or 2161 6 pounds of corn which, when mixed with the 1000 pounds of 32 per cent mixture, would make 3161 6 pounds of a 16 per cent mixture

Any percentage of feed desired can be calculated by substituting the desired percentage for the 16 per cent in these examples Furthermore, if different grains are used either in equal parts or in different proportions, these can be averaged before starting with the square method For example, if one wanted to use equal parts of corn and oats, the average of the protein content of these could be used

$$\left(\frac{8\ 6 + 12\ 0}{2} = 10\ 3\right)$$

If protein supplements other than the 32 per cent protein mixture are used, the same method of calculation is made, or if two different protein supplements are to be used, they could be averaged in the same way as the oats and corn

SELECTING FEEDS FOR A DAIRY RATION

In selecting a combination of feeds to make a ration for a dairy herd, the requirements of a physically satisfactory ration must always be maintained Prices of purchased feeds must also be considered and the selections made on the basis of relative cost and quality

When silage is fed, the problem of getting a palatable and laxative ration is greatly simplified With silage, it is possible, if prices make it desirable, to feed some unpalatable and constipating concentrates The concentrates and the roughages should supplement each other, so that the whole ration fulfills all the requirements of a good ration

Adding Minerals to the Ration

Dairy cows must have salt regularly. It is usually advisable to allow cows free access to it at all times. A popular practice, even though cows have free access to it, is to add 1 pound of salt to each 100 pounds of concentrates, or 20 pounds to each ton.

Legume hay is a good source of calcium, and wheat bran, cottonseed meal, and linseed-oil meal are good sources of phosphorus. If legume hay and one of these concentrates are fed along with other feeds in a balanced ration, the cow's requirements for these minerals are usually met.

If rations known to be low in these elements are fed, or if cows show abnormal appetites for bones, wood, or soil, the ration may be lacking in one or both of these elements. Nonlegume roughages that are grown on soils that have received no lime or fertilizer are usually low in calcium. If calcium is deficient, 20 pounds of finely ground limestone may be added to each ton of grain, or the herd may be allowed access to a mixture of 2 parts of ground limestone to 1 part of salt. The limestone should be ground to such a degree of fineness that 100 per cent of it will pass through a 40-mesh screen. If both phosphorus and calcium are deficient, 20 to 30 pounds of steamed bone meal should be added to each ton of the grain mixture, or the herd may be given access to a mixture of 2 parts of bone meal and 1 part of salt. Dicalcium phosphate or specially prepared rock phosphate that contains less than 0.3 per cent fluorine may be used in place of the bone meal.

Mixing the Ration

When the concentrate ration for the herd has been calculated, the next step is to mix the ingredients together to a uniform mixture. It is necessary that the mixing be done thoroughly; otherwise, different parts of the mixture will differ in composition.

In hand mixing, the different concentrates should be spread out in thin layers on a clean, smooth floor, one on top of another. The salt and mineral should also be added at this time. It is best to put the lightweight ingredients on the floor first, with the

heavier ones on top The entire mixture should then be shoveled over at least 3 times, to insure complete mixing, before it is finally shoveled into the bin or sacks for storage The amount that should be mixed at one time depends upon the size of the herd and upon the storage space Whenever possible, it is well

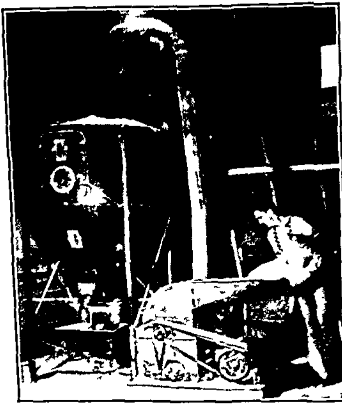


FIG 16 Feed grinder and mixer (*W Va Univ*)

to have each ingredient in the ration in terms of 100 pounds, for in this way the use of a scale is not necessary if the feeds are in 100-pound sacks Of course, this is not possible for the minerals, and sometimes not for other ingredients

For large operations, a half ton or larger mechanical mixer will save much labor This is discussed in Chapter 35 The mechanical mixer will do a more thorough mixing job than is usually done by hand However, hand mixing can be thorough if done properly

DETERMINING THE COST OF THE RATION

The cost of the ration should be figured on every farm. This is especially true of the grain ration, a large proportion of which is often purchased. The following table will show the cost, at given prices, of 100 pounds of digestible protein and 100 pounds of total digestible nutrients of certain feeds.

	Digestible Crude Protein, pounds	Total Digestible Nutrients, pounds	Price per Ton	Price per 100 Pounds	Cost of 100 Pounds of Digestible Crude Protein	Cost of 100 Pounds of Total Digestible Nutrients
Wheat bran	13.7	67.2	$56.00	$2.80	$20.44	$4.17
Ground oats	9.4	70.1	60.00	3.00	31.91	4.27
Corn meal (No. 2)	6.6	80.1	60.00	3.00	45.45	3.74
Cottonseed meal (41%)	32.8	70 6	80.00	4.00	12.19	5.67

The above illustrates how the unit cost of digestible crude protein and total digestible nutrients is determined: by dividing the cost of 100 pounds of wheat bran ($2 80) by the number of pounds of digestible crude protein in 100 pounds of wheat bran (13.7), the cost of 1 pound of digestible crude protein is found to be 20.44 cents; and by multiplying this result by 100 gives $20.44, the cost of 100 pounds of digestible crude protein. In like manner, *dividing the cost of 100 pounds of wheat bran ($2 80)* by the pounds of total digestible nutrients in 100 pounds of wheat bran (67.2) gives 4 17 cents, the cost of 1 pound of total digestible nutrients, multiplying this result by 100 gives $4.17, the cost of 100 pounds of total digestible nutrients. By this method the cost of the digestible crude protein and the total digestible nutrients in each feed can be determined.

It can be seen by the above illustration that, at the prices assumed, the relative cost of total digestible nutrients does not vary so much as that of the digestible crude protein. In the purchase of feeds the cost of these items should be considered rather than the cost of 100 pounds of feed. The most economical ration will usually contain the concentrates that furnish the digestible

crude protein at the cheapest rate as well as that which furnishes the total digestible nutrients relatively cheaply.

REFERENCES FOR FURTHER STUDY

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4 Woodward, Calculating Rations for Dairy Cows *J Dairy Sci*, *14* 173
5 Crandall and Turk, Feeding the Dairy Cow Efficiently, *Cornell Ext Bul* 363 (1936)
6 Heebink and Henderson, Feeding for Profit in Milk Production, *W Va Exp Sta Circ* 74 (1937)
7 Recommended Allowances for Dairy Cattle, *Nat Research Council* (1950)

Heavy milk production is a severe drain upon a dairy cow, and for this reason it is important that the cow be given a rest of 6 to 8 weeks between lactation periods The length of time necessary will depend upon the condition of the cow and the amount of milk which she is producing For a heavy producer or for a cow in poor flesh 2 months should be allowed, so that she will have ample time to rest and store any materials such as calcium and phosphorus which she may need in greater quantities than she can consume during the stress of heavy production and to give time to restore the udder to a normal condition Few cows need less than 6 weeks' dry period

The importance of getting a cow in proper condition when she is dry cannot be overemphasized The condition that she is in at the time of freshening will determine in a large measure the extent of her production She should be in an excellent state of health and carry a surplus of fat when she freshens This fat is available for immediate use to the cow after she freshens, and makes possible a normal increase in production before it is advisable to feed her heavily on a grain ration It has been found that a cow that has been given a good rest and is in good condition at time of freshening will usually produce more heavily than one that has been given little or no rest She will reach a higher daily production early in her lactation period and will continue higher milk production throughout the entire lactation period One of the reasons that cows seem to have alternate off years is that the feeder fails to give them ample time and opportunity to freshen in good condition

Cows that are due to freshen should be turned out daily in fine weather and should be provided with a clean, well bedded box stall

FEEDING THE DRY COW BEFORE PARTURITION

If the cow is dry during the summer or early fall and is on good pasture she will need little extra feed or care before parturition A pasture separate from the general herd is desirable because

there is then less danger of injury Under these conditions the cow will usually need little grain If she is in poor condition, however, she should be fed a ration containing such feeds as ground oats, wheat bran, corn meal, or ground barley The cow should be in good condition at the time of freshening, because her level of production depends on a good start

At the Cornell Station,* a group of cows were fed heavily during one dry period and at a much lower level during another When they were fed heavily they gained on the average 112 pounds more in weight, and in the following lactation produced 705 pounds more milk and 23 pounds more butterfat than they did when they were fed less This increase in weight and production required 440 pounds of concentrates, when the cows were fed in this way, only 62 extra pounds of concentrates were required to produce an additional 100 pounds of milk

If the dry period occurs in the winter the ration should consist of 20 to 30 pounds of corn silage with a liberal amount of legume hay and a grain mixture containing such feeds as linseed meal, wheat bran, ground oats, and, if the cow is in poor condition, corn meal The regular herd ration is often fed with good results, but a ration a little lower in protein is recommended

The following rations have been fed successfully during the fitting period

Ration 1	*Ration 2*
250 pounds ground oats	100 pounds corn meal or barley
200 pounds wheat bran	200 pounds wheat bran
150 pounds corn meal or hominy	200 pounds ground oats
6 pounds salt	100 pounds linseed meal
6 pounds steamed bone meal	6 pounds salt

About a week before the cow is due to freshen, the grain mixture should be changed to a light ration that will keep the bowels in a laxative condition A mixture of equal parts of wheat bran and ground oats is often fed at this time with good results A drastic reduction in total feed intake is not desirable at this time and immediately after calving, since it may cause ketosis (acetonemia) Two or 3 pounds of blackstrap molasses may be fed daily for a week or more before calving This helps to keep

* *Feeds and Feeding*, 21st edition p 719

dence of ketosis and milk fever Freedom from [illegible] troubles are in a large measure due to the care with which a cow is handled during the few weeks previous to parturition

FEEDING A COW JUST AFTER PARTURITION

The grain ration for the first few days after parturition should be light in character and should be fed in small amounts A bran mash made by moistening the bran with warm water is the only grain which should be fed at first It has a cooling effect on the cow and is slightly laxative She can also be given some legume hay and a limited amount of corn silage If the weather is cold her water may be warmed slightly A mixture of oats bran, and linseed meal can be used to replace the bran mash after the first day

GETTING THE COW ON FULL FEED

After the first 3 or 4 days if the cow is in good condition, she can gradually be given the regular herd ration just as fast as her physical condition will permit. If the udder is swollen the amount of grain must be kept down until the congestion disappears Great care should always be exercised in increasing the cow s ration to full feed Often with heavy producing cows full feed will not be reached for a month or even longer after parturition The heavy milking cows usually lose weight during the first month as they are drawing on their reserve for milk production

Under ordinary conditions one can begin on the fourth or fifth day after freshening to feed 4 or 5 pounds of the regular grain ration and this can be increased at the rate of 1 pound every 2 or 3 days until the cow reaches her maximum production It is often hard to judge when the maximum has been reached The cow should be given enough feed to supply the amount needed in the milk and to keep her from dropping off in her weight. If she is giving 30 pounds of milk per day and is receiving 9 pounds of grain and if it is not sure that she has reached her maximum production the feed should be increased slowly to possibly 12 pounds and the effect upon the cow watched care

fully. If she responds with more milk, then a further increase should be attempted If, however, she does not give any increase in milk production within 2 or 3 days, the amount of grain should be gradually diminished until she is receiving just the amount to which she will respond

FEEDING THE MILKING HERD

In feeding the milking herd for production, it is well to keep in mind the requirements for a good dairy ration, which have been brought out in a previous chapter A cow should receive an abundance of feed, containing plenty of nutrients in the correct proportions and made up of feeding stuffs that are palatable and economical The other requirements of a good ration should also be given consideration

Weight a Good Index. The condition of the cow is a good index as to whether she is being properly fed A cow usually loses weight during the first 4 to 6 weeks of her lactation, the amount lost depending upon her condition at the time of freshening and her ability as a producer For the next 5 to 6 months the weight of the cow should remain fairly constant, the exact length of time depending upon the time of her next calving

From 2 to 4 months before parturition the cow usually increases in weight, partly on account of the growth of the fetus, but more largely on account of the storage of body fat which may later be used for milk production The cow should be so fed that she will not lose weight during the greater part of her lactation period

Feeding Cows as Individuals. The dairy cow should be fed as an individual Each cow has her peculiar likes and dislikes, and these must be catered to if the best results are to be obtained It is never advisable to feed all cows in the herd the same amount, as each has different requirements Some are larger than others, some give more milk than others, and some give milk of higher quality than others All these factors should be taken into consideration Heifers during their first and second lactation periods should be fed a little more liberally than mature cows, because they are still growing Cows that possess a highly

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nervous temperament are often fed a ration with a wider nutritive ratio than those that tend to take on fat.

Avoid Overfeeding. Although liberal feeding is advisable, overfeeding must be guarded against. If a cow is being fed more than she requires for milk that she is producing, she is probably storing up fat which, although not entirely wasted, is not giving any immediate return. It would be much better if the cow were fed just as much as she requires for the milk she is producing. Anything over that amount is largely wasted. Sometimes, overfeeding results in the cow's going off feed. If this happens, the grain ration should be immediately cut down, and the cow should be fed only light, laxative feeds for a few days. After this she may be slowly put back on her full ration.

The Amount of Nutrients Required for the Growth of the Fetus. It has always been known that, with the onset of pregnancy, the dairy cow must provide the nutrients not only for the production of milk but also for the building up and maintaining of the developing fetus. Eckles * found from experimental results that the amount of nutrients necessary to develop the bovine fetus is so small that it cannot be measured by ordinary means of experimentation. He analyzed four Jersey calves at birth and found that they contained an average of 73.09 per cent of water. The amniotic fluid weighed about 30 pounds, 95 per cent of which was water. The placenta weighed 18 pounds, approximately 85 per cent of which was water. A Jersey cow, on this basis, produces a total of only 15 to 20 pounds, and the Holstein 20 to 25 pounds of dry matter in the fetus and accompanying fluid and membrane. Eckles found that, on a dry matter basis, a Jersey calf at birth is equivalent to 110 to 170 pounds of Jersey milk, and that the Holstein calf is equivalent to 200 to 275 pounds of Holstein milk. Other investigators have found that the carrying of the calf was a slight but significant drain upon the mother's milk production. All experimental work points to the fact that the amount of feed required to grow the fetus is not such that it must be seriously considered during the feeding period. More than 75 per cent of

* *Mo Agr Exp Sta Res Bul. 28*

the fetal growth takes place after the seventh month of pregnancy *

Order of Feeding. The cow is a creature of habit and expects her feed at regular intervals Regularity is much more important than any order of feeding, although to give the feed regularly some system of feeding must be followed There is, perhaps, no best order of feeding, but certain factors should be considered Hay, which is likely to cause dust in the barn, and feeds such as silage and roots which tend to impart taints to the milk, should be fed after the milking rather than before The grain is often fed before the milking or at the time of milking Frequently, it is desirable to feed the grain on the silage If this is done it does not seem necessary to have so much bulk in the grain mixture

A good system would be to feed the grain before milking and the silage just as soon as the milking was done The hay could then be fed just as soon as the cows had finished their silage This would give time to turn the cows out, in fine weather If corn stover were to be fed it could be fed out in the lot at this time The same order could be followed in the evening This would leave the mangers filled with hay the last thing at night so that the cows would have as much time as necessary to clean it up When cows are milked oftener than twice a day the number of feedings is usually increased

Feeding Equipment The farm should be so arranged and the equipment should be such that the feeding can be done with a minimum amount of labor The grain should be kept, if possible, in bins on the second floor, from which it can be run directly into a feeding truck If this is not possible it can be kept in sacks or in bins in a room on the first floor, where it can be poured or shoveled into the feeding truck The truck may be run on a track in front of the cows, or it may be on wheels and be pushed in front of them Often, in the smaller dairies, the grain is kept in a large feedbox in the barn and the feeder simply feeds out of this box Whatever the system, it is very necessary that the feed be kept well covered or out of reach of the cows, as they are very likely to be foundered if they do get

* U S D A *Tech Bul* 964

to it The choice of a system should depend upon the size of the herd It is usually advisable to weigh the feed to each cow Some dairymen, however, prefer to measure it This can be done if the feeder is careful to weigh a measure or two and so become accustomed to the amount which the measure will hold

FIG 17 A feed cart, a scoop and a feed chart make accurate feeding easier (W Va Univ)

It should always be borne in mind when feeding by measure, that feeds vary considerably in weight In any method there should be a simple feed sheet to show the amount that each cow is to be fed

For convenience in the feeding of silage, the silo should be reasonably near the cow barn The silage in the smaller dairies is often pitched out of the silo upon the barn floor, whence it is carried in baskets to the cows In larger dairies it is usually thrown into a silage truck which runs either on wheels or on a track and which may be pushed around in front of the cows as

in feeding the grain. Beets can be fed in the same way. They are usually stored in a root cellar, which should be easily accessible.

The hay chute from the mow should be located in a convenient place where the hay can be thrown down into the barn and from there fed to the cows in the quantities desired. The hay may be loaded into a small hayrack, the weight of which is known, and pulled on to scales. In this way the actual weight of the hay for the entire herd may be determined. It can then be distributed according to the feeder's judgment. When baled hay is fed it is much easier to handle, but unless care is taken there is a tendency to feed more than when the hay is fed loose.

PREPARATION OF FEEDS

Grinding. The grinding of grains increases their digestibility only if they are hard seeds which otherwise might pass through the digestive tract unbroken. Experiments [*] have shown that when dairy cows were fed whole grains, such as corn and oats, 30 to 35 per cent of the corn and 20 to 25 per cent of the oats passed through the animal in the feces undigested. Not only is there a considerable loss in the utilization of the feed, but cows cannot be maintained at a high level of production on unground grains, even though a large quantity of it is fed. Grains should be ground to a medium degree of fineness rather than finely ground. Calves, until they are 6 to 8 months of age, masticate whole grains very thoroughly. It is always advisable to grind the grain for all dairy cattle except calves.

As a rule it is not profitable, nor does it increase digestibility, to chop roughages. When cut, however, they are easier to feed and the cows will usually eat more of the coarser parts. This is especially true of lower-grade hays and stover. When high-producing cows consume the coarser parts in this way, they are not able to consume as much total nutrients as if they ate only the finer part of the hay and were fed more liberally.

Chopped roughages do have the advantage that less space for storage is required, and under some conditions they may

[*] *Ind. Exp. Sta. Bul.* 372.

be stored more easily than long hay. Uneaten portions of chopped roughages are convenient to use for bedding.

When roughages are scarce and high in price and when they are so coarse that the cattle refuse a considerable portion of them chopping may be economical. There is no advantage in chopping good roughage, it does not increase its feeding value.

The feeding of limited roughage in a finely ground state along with a liberal amount of grain will reduce the fat test of the milk.*

Soaking. As a general rule, the soaking of grain is not necessary as it does not improve its digestibility or palatability. However, wheat bran is often mixed with warm water in which condition it is known as bran mash. It is a good conditioner for cows just before and after freshening or at other times when they are out of condition. It has been shown† that when cows are given free access to water there is no advantage in soaking beet pulp or other feeds.

Predigesting. Predigesting roughages by means of converters, in which the roughage is cut, mixed with a starter or converter, packed into drums or wooden tanks, then steamed or soaked with warm water and allowed to stand for a sufficient length of time for fermentation to take place, has not proved economical.‡ The dairy cow seems to be able to convert her own roughages more economically than can be done by the feeder. The cow's rumen is often referred to as a fermentation vat.

Effect of Feeding on the Fat Percentage. It is a general belief among feeders that the ration influences the fat percentage. Experimental data have not shown this to be true, although some feeds may have a stimulating effect for a short time. The effect of feeds high in fat is only temporary. Ground flaxseed and soybeans perhaps have as great an influence as any of the feeds and even their effect is not pronounced and some cows may not respond to them.§

Influence of Stage of Lactation on Milk Yield. The effect of stage of lactation upon milk production is quite well known.

* *Proc Am Soc Animal Production* 1938 p 40 *J Dairy Sci* 28 147
† *J Dairy Sci* 16 363
‡ *Ohio Exp Sta Bi Monthly Bul* 150
§ *J Dairy Sci* 10 70

Data taken from 428 lactation periods at the Iowa Experiment Station * show that, in Jerseys and Guernseys, the highest milk yield is obtained during the first month of lactation and from that time on there is a very gradual decline until the eighth or ninth month, after which there is a very rapid decline until the end In Holsteins and Ayrshires the second month is the highest in milk production, and from then on the decline is very similar to that of other breeds

Influence of Stage of Lactation on the Percentage of Butterfat. The most extensive study that has been reported concerning the effect of stage of lactation upon the percentage of fat is that of Ragsdale and Turner † They used a total of 4045 cows, consisting of 3763 advanced-registry cows of the Guernsey breed, 299 register-of-merit cows of the Jersey breed, and 95 Holsteins from the University of Missouri herd Their results show that with the Jersey and Guernsey breeds the percentage of fat dropped off from the first month to the second and there was then a very gradual increase from month to month until about the ninth or tenth month, after which there was a somewhat greater increase The Holstein breed followed the same general curve, with the exception that they did not reach the low point until the third month Table XI gives the results

FEEDING DAIRY COWS

Feeding Cows in Summer. Fresh, lush pasture is the best feed for dairy cows, it is nutritious, abundant, and cheap, and more palatable than any other feed No feed is more nutritious, as it contains everything including minerals and vitamins necessary for heavy milk production In the heavy growing season it is abundant, and milk can be produced cheaper with pasture than with any other feed The cows harvest it themselves

Pastures, however, are not always good Few native pastures furnish an adequate amount of feed in its best form throughout the entire summer They vary in types of plants, stage of maturity, composition, succulence, and palatability during the sea-

* *J Dairy Sci*, 7 255

† *J Dairy Sci*, 5 22

TABLE XI

INFLUENCE OF STAGE OF LACTATION UPON THE PERCENTAGE OF BUTTERFAT

Month of Lactation	Guernseys (3763), per cent	Jerseys (299), per cent	Holsteins (95), per cent
1	4 63	4 89	3 24
2	4 59	4 82	3 01
3	4 71	4 88	2 99
4	4 85	5 10	3 02
5	4 97	5 13	3 01
6	5 08	5 26	3 08
7	5 16	5 40	3 11
8	5 22	5 43	3 16
9	5 29	5 50	3 19
10	5 39	5 58	3 27
11	5 49	5 60	3 32
12	5 60	5 73	3 49

son It is therefore impossible to make any general recommendations for supplementary feeding of dairy cows while on pasture

When on lush, tender grass that is abundant, a cow may graze as much as 150 pounds of grass per day * When the grass has partially matured and is not so plentiful, and when heat and flies bother the cows, they may graze less than 50 pounds of grass per day

Early grass, moreover, is high in moisture, averaging 75 to 85 per cent, whereas more mature pasture may contain only 60 to 70 per cent moisture The nutrients do not vary in direct proportion to the dry matter Young grass is more highly digestible than older grasses Young grass also is high in protein, which decreases as the grass matures and ripens

Under conditions found in most of the United States, the average dairy cow will produce heavily in the early part of the summer on grass alone but rapidly drops off during the latter part of the summer Such cows will not usually come back in milk flow and will produce but little milk during the winter

* *J Dairy Sci*, 19 347, 1936

Cause of the Decrease in Late Summer. The cause of this decline in milk production in late summer has been attributed to several different causes One of these is the annoyance of flies, but the effect of flies is slight and in these days when fly-sprays have been developed that keep most of the flies off the cows, *it can be almost entirely eliminated* The second cause is the effect of heat on the cows It is true that heat does have some effect on milk production Cows cannot withstand long, continuous temperatures much above 80°F without going off in milk production However, in very few sections of the country does the temperature remain above 80°F for long periods of time When it does, milk production will be lowered There are some breed differences, since certain breeds can stand more heat than others, but as a whole the differences are small

The chief reason for the falling off of the milk production seems to be a question of feed As the pasture matures, it becomes less palatable, less digestible, less nutritious, and often in areas where the rainfall is short, an actual shortage of grass may occur That the chief reason for the drop in milk production is one of feed supply is proved by the fact that when cows are given an abundance of feed, they will keep up in their milk production all through the summer months Only too often the kind of pasture available in the summer offers sufficient reasons for the decrease in production The cows are not able to consume a sufficient supply of nutrients to maintain their production and will gradually go down in milk

How to Maintain Summer Milk Production

1 Improve Pasture Species Many of the native grasses ripen and make but small growth during the hot weather, especially when the weather is dry Several varieties of legumes and grasses have been developed that will withstand the heat and dry weather and make good growth throughout the summer Many farmers are seeding such pastures and are getting good pasture throughout the entire season

2 Supplemental Pastures Some dairymen are growing a temporary pasture, such as Sudan grass, which grows well in the

hot, dry months of summer and furnishes the extra feed needed during this period

3 SOILING CROPS A few dairymen grow a green crop and harvest and feed it to the cows when it is green These are called *soiling crops* They are good feeds but usually require too much labor for harvesting and seeding to be practiced

4 SUMMER SILAGE One of the best methods of providing extra feed to the cows during this period is to feed some silage This silage may be either a hay crop silage or corn silage Many dairymen are putting that part of the pasture which cannot be used in early summer into a silo and feeding it out later in the summer when extra feed is needed, thus making double use of the silo

5 HAY Most dairymen have difficulty in having sufficient hay for the winter feeding period and hesitate to feed it during the summer Cows can be kept in milk flow during the summer by the use of good hay but the cost of harvesting, storing, and feeding it is considerable

Grain Feeding on Pasture. Even good pasture or pasture supplements will not usually supply a cow with sufficient nutrients to produce more than 30 to 40 pounds of milk per day unless she is fed grain in addition Some exceptionally good pastures may exceed this, but most pastures will not maintain even this level of production It is necessary, therefore, if production is to be maintained, that grain be fed Most dairymen who are producing milk for the fluid milk market feed grain during the pasture season, but many of those producing milk for manufactured products, sour cream and the like, depend entirely upon the pasture for feed for their herds In this case the cows decrease in production to a low level in the later part of the summer and continue at a low level during the winter months The amount of grain to feed a cow on pasture should be based on the amount and quality of pasture available and on the relative cost of feed as compared to the selling price of the milk. Table XII gives the recommended amounts of grain to feed under different conditions of pastures, size of cows, and their butterfat test.

TABLE XII

Grain Feeding Guide for Cows on Pasture *

Pounds of Milk Produced Daily	Pounds of Grain Required Daily			
	By a 1200-Pound Cow Testing 3.5% When Pasture Is		By a 1000-Pound Cow Testing 5% When Pasture Is	
	Good	Fair	Good	Fair
10	..	....	....	1.0
15	..	1.5	....	3.5
20	..	3.5	1.5	6.0
25	2	5.5	4.0	8.5
30	4	7.5	6.5	11.0 †
35	6	9.5	9.0	13.5
40	8	11.5 †	11.5 †	16.0
45	10	13 5	14.0	18 5
50	12 †	15.5	16.5	
55	14	17.5	19.0	
60	16			
65	18			

* *W. Va. Exp. Sta. Circ.* 74.

† Never feed a cow more grain than she can safely handle. Cows in heavy production may "go off feed" when fed the amounts of concentrates required to maintain both a high level of production and body weight.

Feeding Cows in Winter

The best and most economical basis of winter feeding of dairy cows should be high-quality legume hay and good silage, which are fed to replace pasture. Grain should be fed only in sufficient amounts to supply the nutrient needs of the cow above what she is able to secure from roughage. Cows on good roughage alone can be expected to produce approximately 70 per cent as much milk as when they are fed a normal amount

of grain If they receive one half the normal grain allowance they can be expected to produce about 90 per cent as much milk as they would if fed grain in normal amount These figures refer to conditions when the roughages are of high quality and fed in liberal amounts Unfortunately, most of the roughage now being produced will not give such results

Woodward * found that good cows fed only good alfalfa hay with a phosphorus supplement would produce about 250 pounds of butterfat in a year When good corn silage in addition to the alfalfa hay was fed, these cows produced 275 pounds of butter fat per year, and when they were also grazed in good pasture during the grazing season it was possible to secure 300 pounds of butterfat per year These results were secured when the hay, silage, and pasture were all of high quality and the cows were fed all that they could consume

Amount of Concentrates to Feed The practice of feeding all cows in the milking herd the same amount of grain is costly because it usually underfeeds the best producers and overfeeds the low producers in the herd The amount of grain required by cows varies according to the quantity and richness of their milk and the quality of the roughage ration

Several guides are commonly used to the amount of grain that should be fed to individual cows They are as follows

1 Based on Amount of Milk Produced This plan was one of the first adapted and is the easiest system to use Because of its simplicity it is used extensively, although other systems are more exact.

With average roughage feeding (2 pounds of hay, or 1 pound of hay and 3 pounds of silage per 100 pounds of body weight), feed

Jersey and Guernsey 1 pound of grain mixture for each 2 5 to 3 pounds of milk produced,

Ayrshire, Brown Swiss, or *Grades* 1 pound of grain mixture for each 3 to 3.5 pounds of milk produced,

Holstein 1 pound of grain mixture for each 3.5 to 4 pounds of milk produced

2. Based on Fat Production This plan is more difficult to apply, since most dairymen have no definite knowledge of the

* *Proc Am Soc of Animal Production* (1940)

weekly butterfat production. The rule is: feed 1 pound of grain mixture per day for each pound of butterfat produced per week.

Neither of the above guides take into account variations in the quality of the roughages They will tend to overfeed the low producers and underfeed the high producers The average cow would be fed about right

3 BASED ON ROUGHAGE FEEDING This guide is based on the liberal feeding of good-quality roughage, and on the assumption that the cow will secure sufficient nutrients for her maintenance and for a limited amount of milk from her roughage. For production above this designated amount, the cow would be given some grain as follows [*]

Breed	Milk Produced on Roughage, pounds	Grain Allowance for Each Additional Pound of Milk, pound
Jersey	10	0 60
Guernsey	12	0 55
Ayrshire and Brown Swiss	14	0 45
Holstein	16	0 40

As an illustration, suppose a Jersey cow was producing 30 pounds of milk, then she should be fed 0 6(30 − 10) or 12 pounds of grain per day, or a Holstein cow producing 40 pounds of milk should be fed 0 4(40 − 16), or 9 6 pounds per day

4 USING A TABLE THAT DESIGNATES TYPE OF ROUGHAGE Table XIII may be used as a guide in determining the amount of grain to feed It gives consideration in a general way to variations in daily milk production, in butterfat test, and in the quality of roughage fed To use the table, first determine whether the roughage would be classed as good or fair Good roughage includes well-cured, green, leafy hay fed with or without silage Fair roughage includes hay of poorer quality than that referred to above, fed with or without silage or limited amounts of straw or stover. The next step is to consider the daily milk production and its test. To illustrate, a cow giving 25 pounds of milk testing 5 per cent and receiving good roughage would require 8 pounds of grain daily, or if the roughage was fair, the grain

[*] *USDA Misc Publ* 130 *Nev Exp Sta Bul* 116

requirement would be 11 5 pounds A cow giving 35 pounds of 3 5 per cent milk on good roughage would require 9 pounds of grain or on fair roughage 12 pounds of grain daily

TABLE XIII

GRAIN FEEDING GUIDE FOR STABLE-FED COWS

Pounds of Milk Produced Daily	Pounds of Grain Required Daily			
	By Cows Testing under 4 Per Cent When Roughage Is		By Cows Testing over 4 Per Cent When Roughage Is	
	Good	Fair	Good	Fair
15	1	4	3	6 5
20	3	6	5 5	9
25	5	8	8	11 5 *
30	7	10	10 5 *	13 5
35	9	12 *	13	16
40	11 *	14	15 5	18
45	13	16	18	20
50	15	18	20 5	22
60	17	20		

* Never feed a cow more grain than she can handle with safety Many cows in heavy production will not remain in good health when fed the amounts of grain required to continue heavy production without loss of live weight

5 LIMITED AMOUNT OF GRAIN Many successful feeders limit the amount of grain that they will feed the individual cow and will not feed more than a certain amount no matter how much milk they are giving. This limit is usually about as follows

Jersey cows 12 pounds of grain daily
Jersey (first calf) 10 pounds of grain daily
Guernsey and Ayrshire cows 14 pounds of grain daily
Guernsey and Ayrshire (first calf) 12 pounds of grain daily
Holstein and Brown Swiss cows 16 pounds of grain daily

Holstein and Brown Swiss (first calf): 14 pounds of grain daily.

The cows are given all the good-quality roughage that they will eat, and are fed grain according to production with two exceptions: (1) when the amount of milk produced requires more feed than is given above, and (2) when the amount of milk produced requires less than 4 to 8 pounds per day. In the latter case, they continue to feed the 4 to 8 pounds. This of course means that the heavy-producing cows are being underfed and must draw on their reserve to keep up the milk flow, and that the low-producing cows are overfed and will put on weight at the end of the lactation and therefore will replenish their loss and build up a reserve to last into the next lactation. Cows fed in this way seldom go off feed. Usually, animals that go off feed cannot be brought back to their production. Cows seem to be able to maintain heavy milk flow for several months if they are in good condition, even though the grain ration is limited. They may lose flesh but later they have a chance to make up this loss in weight by being overfed during the latter part of the lactation and during the dry period. The amount of feed required to feed by this system is about the same for the entire lactation as when they are fed according to their production.

The feeding of insufficient feed nutrients to the milk cows of this country is the one greatest limiting factor in the production of milk. The next limiting factor is not feeding a balanced ration (refer to Chapter 10), that is, feeding insufficient protein.

GRAIN MIXTURES

There is no one combination of feeds that is far superior to another mixture that can be formulated. Some mixtures are simple, containing only a few ingredients, usually mostly farm-grown feeds. Other mixtures are more elaborate or complex, containing a large number of ingredients.

When good quality roughages are fed, simple mixtures give equally good results as more complex mixtures. There are probably some exceptions to this, where the greater variety is more palatable and exceptionally high-producing cows may consume a greater quantity of the feed.

Six formulas for dairy feeds are given below with their analyses.

Mixture No. 1 *

700 pounds corn-and-cob meal
200 pounds ground barley
100 pounds cottonseed meal

1000 pounds

T. Prot.†	11.8 per cent
D. Prot.	9.0 per cent
T.D.N.	73.8 per cent

Mixture No. 2

700 pounds ground corn
200 pounds wheat bran
100 pounds soybean-oil meal

1000 pounds

T. Prot.	13.8 per cent
D. Prot.	11.1 per cent
T.D.N.	77.4 per cent

* One per cent salt should be added to all rations; also, minerals when needed.

† T. Prot. (total protein); D. Prot. (digestible protein); T.D.N. (total digestible nutrients).

Mixture No. 3

300 pounds ground barley
300 pounds ground corn
200 pounds ground oats
100 pounds wheat bran
100 pounds linseed-oil meal

1000 pounds

T. Prot.	14 0 per cent
D. Prot.	11.3 per cent
T.D.N.	75.8 per cent

Mixture No. 4

500 pounds corn-and-cob meal
200 pounds ground oats
300 pounds peanut-oil meal

1000 pounds

T. Prot.	19.1 per cent
D. Prot.	16.4 per cent
T.D.N.	75.3 per cent

Mixture No. 5

200 pounds ground corn
100 pounds ground barley
100 pounds ground oats
200 pounds wheat bran
100 pounds linseed-oil meal
100 pounds cottonseed meal
100 pounds molasses
100 pounds corn-distillers' grains

1000 pounds

T. Prot.	18 4 per cent
D. Prot.	14 5 per cent
T.D.N.	72 5 per cent

Mixture No. 6

100 pounds ground corn
100 pounds ground oats
200 pounds wheat bran
200 pounds linseed-oil meal
200 pounds cottonseed-oil meal
100 pounds molasses
100 pounds corn gluten feed

1000 pounds

T. Prot.	23 6 per cent
D Prot.	19 2 per cent
T.D.N.	71 0 per cent

The above formulas contain high quality grains and by-product feeds The digestible protein ranges from 9 0 to 19 2 per cent and the total digestible nutrients range from 71 0 to 77 4 per cent

A formula may contain some low nutrient feeds A feed of this kind would have a lower feeding value The following is a formula for such a feed

Mixture No 7

300 pounds corn and cob meal
300 pounds oat mill feed
300 pounds brewers' grains
30 pounds synthetic urea
70 pounds citrus pulp

1000 pounds

T Prot 20 4 per cent
D Prot 14 2 per cent (considering urea 60 per cent digestible)
T D N 58 6 per cent

Breeders who are pushing their cows for high official test records will use the best feeds and will feed more liberally The cost is not so great a consideration as in general herd feeding Where cows are fed heavily and pushed for high records, the feeder must be capable of getting the most possible nutrients into the cow and still keep her on feed

Carnation Ormsby Madcap Fayne a former national champion milk producer with a record of 41 943 pounds of milk in 1 year was fed daily * throughout the year an average of

35 pounds alfalfa hay
20 pounds corn silage
40 pounds sugar beets or mangels
10 pounds kale or cut fresh grass
18 pounds grain mixture (wheat mixed feed, soybean-oil meal, ground corn, linseed oil meal, ground oats, corn germ meal, and minerals)

Planning the Feeding Program Profitable feeding requires planning for the winter feed supply A dairyman should make

* *Carnation Milk Farm News*, 23 1

certain that he has sufficient feed to carry the herd until the next harvest. If feed must be purchased, it should be purchased at the season when it is lowest in price. The estimated yearly amount of feed required by dairy animals is given in the table.

TABLE XIV

ESTIMATED AMOUNT OF FEED REQUIRED BY DAIRY ANIMALS FOR A YEAR

Kind of Livestock	Feed Required Each Head per Year				
	Without Silage		With Silage		
	Dry Roughage, tons	All Concentrates, pounds	Dry Roughage, tons	Silage, tons	All Concentrates, pounds
Cows weighing 1000 pounds and giving 6000 pounds of 4 per cent milk	2½	2000	1½	3	2000
For each 1000 pounds more milk add		300			300
Dairy heifers 1–2 years	1½	600	1	1	600
Dairy calves under 1 year	1	500	¾	½	500

The feeding and handling of a dairy herd so as to secure a profitable amount of milk from them requires a broad knowledge of feeds and how the cow uses them. The feeder must be able to observe the response of his cows to their feed.

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12

Effect of Abnormal and Unusual Rations

The efficient production of milk usually calls for feeding a well balanced ration, fortified in all the essentials of a good ration and divided between roughages and concentrates Many times however such rations are not fed, either because of ignorance on the part of the feeder, or because of abnormal conditions which justify a departure from ordinary methods A feeder however, should understand what should be expected under such conditions The following discussion will give some experimental evidence on the results obtained by different methods of feeding.

FEEDING UNBALANCED RATIONS

A ration is said to be balanced when it contains the different nutrients in the proper proportion to meet all the requirements for maintenance and production. When any of the necessary constituents are not given in sufficient quantities the animal cannot produce milk up to the limit of her ability A cow cannot change materially and permanently the composition of her milk, and its production is controlled by the constituents of her feed An excess of protein for instance may be used to some extent for the production of energy, although it is not usually economical to produce energy in this way An excess of energy producing material, however cannot take the place of protein

Insufficient Feed. One of the common mistakes that many feeders make is to use insufficient feed—rations low in both protein and energy The intelligent feeding of dairy cows is of greater importance than is often realized Many cows that are now causing a loss to their owners would yield a good return if

fed properly The tests below show that the milch cows of the United States are probably much better than their records indicate The feeding of sufficient feed would no doubt greatly increase the average production of the cows in this country

An experiment conducted at the Maryland Experiment Station [*] shows the effect of good feeding A herd of eight cows was kept under observation by the station on a farm for 1 year The following year the same animals were kept at the station, where a good feeding system was followed Table XV shows the effect of proper feeding on ordinary cows

TABLE XV

COMPARISON OF FEEDING METHODS

(Maryland Experiment Station)

Number of Cows	First Year, on Farm, pounds of milk	Second Year, at Station, pounds of milk	Average Pounds Milk per Day best week, first year	Average Pounds Milk per Day, best week, second year
1	4004	6092	27	40
2	4122	5051	21	33
3	5192	6163	27	40
4	4537	6134	27	48
5	6097	6995	31	35
6	4035	7995	27	57
7	6357	6828	38	33
8	4653	5465	24	37

A similar experiment, though somewhat more extensive, was undertaken by the New York Experiment Station [†] A herd representative of the cows in the farming community near Cornell University was selected During 1 year, these cows were fed and handled by their owner, but records of the feed used and the milk produced were kept by the experiment station The following 2 years the animals were kept in the college barns and fed balanced rations They were then returned to the farms, where records were kept for the fourth year Table XVI shows the average yearly production during the 4 years and the length

[*] Data furnished to one of the authors by Doane

[†] N Y, *Cornell Exp Sta Bul* 222

TABLE XVI

INFLUENCE OF LIBERAL FEEDING ON PRODUCTION

Year	How Fed	Average Yearly Production: Milk, pounds	Fat, per cent	Fat pounds	Lactation Period weeks
1900	Poorly	3360	4 4	148	34
1901–1902	Liberally	6621	4 6	301	43
1903	Poorly	4492	4 3	190	39

of the lactation period This table shows that the cows, during the 2 years at the college produced a yearly average of 2695 pounds more milk and 132 pounds more fat than they averaged during the 2 years at the farm The increased production in 1903 over 1900 was probably due to their improved physical condition after 2 years of proper feeding Proper feeding increased the length of the lactation period from 34 to 43 weeks Needless to say, not only was there an increase in production but also the enterprise was much more profitable when they were fed liberally

Heavy Feeding It is usually profitable to give to cows that have the ability to produce large amounts of milk all that is necessary in order to reach their normal limit of production The amount of feed required for maintenance by cows of the same weight is practically the same and the differences in production are due to the amount of feed consumed over that required for maintenance This being so, it is more profitable to produce milk from a cow that will produce 20 pounds than from one that will produce only 10 pounds The higher producer is more economical because she produces more milk with the same amount of food for maintenance as the low producer Two of the low producing cows must be maintained to produce the amount of milk that is obtained from one of the higher producers Although it is true that high production is the most economical it does not follow that cows should be forced to the limit of their production The last few pounds may cost more than they are worth. There is a point in the feeding of dairy cows where it is not profitable to use more feed in order to get a higher production. The law of diminishing returns is brought into operation

because the proportion of concentrates required is greatly increased, with the result that a very high percentage of the feed comes from the high priced concentrates In advanced registry feeding it may pay to get the last few pounds of milk from the cow because of the value of the record The extra milk, however, may be produced at an actual loss

Research has been carried on at a number of the experiment stations to determine the economy of heavy and normal feeding for dairy cattle In an experiment at the Wisconsin Experiment Station * sixteen cows were fed what are called, respectively, heavy and normal rations The heavy rations consisted of an average of 110 pounds of dry matter for each 100 pounds of milk and an average of 23 8 pounds of dry matter for each pound of fat The normal rations averaged 81 8 pounds of dry matter for each 100 pounds of milk and an average of 21 7 pounds of dry matter for each pound of fat

All the cows in the lot fed the heavy grain rations consumed more dry matter to a pound of milk and butterfat than those fed the normal ration The cows fed the heavy ration did not maintain the full flow of milk during the following 2 months of the experiment any better than the normally fed cows There was actually a small difference in favor of the normally fed animals, perhaps owing to digestive disorders or to overfeeding The conclusion drawn from the experiment was that it was unprofitable to feed the cows more than a medium amount of grain unless they were animals with marked dairy tendencies It has been found that dairy cows will digest a medium to low ration better than a heavy one

Rations Low in Protein In an experiment at the Illinois Experiment Station,† two groups of ten cows each were fed rations equal except in amount of protein, as follows

Lot 1	Pounds	Lot 2	Pounds
Corn silage	30	Corn silage	30
Clover hay	8	Timothy hay	5
Gluten feed	4⅔	Clover hay	3
Ground corn	3⅓	Ground corn	8

* *Wisc Exp Sta Bul* 116
† *Ill Exp Sta Bul* 159

The ration of the first lot contained 1 pound of digestible protein to 6 pounds of digestible carbohydrates and fats, which is a balanced ration for cows giving 40 pounds of milk daily. The ration of the second lot contained 1 pound of digestible protein to 11 pounds of digestible carbohydrates and fats, which is a ration too low in protein for cows giving 40 pounds of milk.

Lot 1, which received the balanced ration, produced 1.7 pounds more milk during the preliminary week of the trial, during the second week or the first week of the trial, the increase was 5.8 pounds for each cow daily, and in the seventh week the gain was 13.2 pounds. The average for the 19 weeks of the test was 10.65 pounds of milk for each cow daily, in favor of the cows fed the balanced ration.

The cows receiving the balanced ration produced approximately one third more than those receiving the low protein ration. Six and one half cows on the balanced ration produced as much as nine cows on the ration low in protein.

The cows that received the balanced ration were in better physical condition and had good flesh at the end of the trial, whereas those receiving the unbalanced ration lost greatly in flesh and their subsequent production was also reduced. The carbohydrates and fats could not take the place of the protein.

Rations High in Protein. In a research project at the Virginia Experiment Station * a group of cows was fed a ration high in protein. The ration consisted of 2 pounds of cottonseed meal, 2 pounds of bran, 7 pounds of corn gluten meal, and 40 pounds of silage. This had a nutritive ratio of 1:2.4, and the grain ration contained 28.2 per cent of digestible protein. The cows refused 25 per cent of their ration, but the amount they consumed supplied them with sufficient energy and 2½ times as much protein as was necessary. The excess amount of protein was digested, and the coefficient of digestibility of it and the other nutrients agreed very closely with the average coefficients. The cows were able to use this excess protein by voiding the excess of nitrogen in urine and using the remainder to furnish energy or to supply fat. The animals on this ration were in excellent condition throughout the experiment.

* *Va Exp Sta Tech Bul. 12.*

AMOUNT OF PROTEIN TO FEED Although an excess of protein may not seem to be detrimental to the cow, yet for economical milk production it is usually best to feed somewhat near the minimum requirements A study was made at the Cornell Experiment Station * in which the production of cows fed a 24 per cent protein grain mixture, a 20 per cent protein grain mixture, and a 16 per cent protein grain mixture was compared All cows were fed mixed hay and corn silage The experiment extended over a period of 3 years, and the results are given in Table XVII The

TABLE XVII

PRODUCTION OF COWS ON VARYING LEVELS OF PROTEIN FEEDING CORNELL EXPERIMENT STATION

Protein, per cent	Production of Milk in Pounds 1928–1929	1929–1930	1930 1931
16	9,262	9577	9565
20	10,066	9689	9673
24	9,410	9804	9542

conclusion of this study was that a 16 per cent total protein con centrate mixture, fed with No 2 timothy clover mixed hay, and corn silage as roughage, gave as high production when fed at the rate of 1 pound of concentrates to each 3½ pounds of milk produced as either a 20 per cent or a 24 per cent total protein concentrated mixture There was no evidence of a stimulating effect of protein on milk secretion The 16 per cent ration fur nished sufficient protein for maintenance and 127 8 per cent of the protein required for the production of the milk and seemed to be adequate for efficient and economical milk production

Rations High in Energy The workers at the Virginia Experi ment Station † also fed a group of dairy cows a ration high in energy but containing sufficient protein when the average diges tion coefficients were used This ration consisted of 9 pounds of corn meal 2 pounds of wheat bran and 40 pounds of corn silage The nutritive ratio of the ration was 1 11

The cows fed this ration consumed almost all their food and consequently obtained a large surplus of energy However, abil-

* *Cornell Exp Sta Bul* 540

† *Va Exp Sta Tech Bul* 12

ity to digest the nutrients decreased until the energy dropped to the requirements of the body for maintenance and milk production Digestibility of protein decreased 47 per cent, hence, they were unable to maintain flesh and decreased in weight rapidly The digestibility of crude fiber dropped 54 per cent, nitrogen free extract 24 per cent, and fat 19 per cent. The average digestibility of all the nutrients in the ration was 23 per cent below the average coefficients as ordinarily given

FEEDING WITHOUT ROUGHAGE

The cow's stomach is especially adapted for the handling of a large amount of roughage, and it is believed by practical dairymen that a ration must contain some of the coarse feeds, such as hay or silage However, experiments conducted a number of years ago by Miller showed that dry dairy cows could be maintained for 8 weeks on corn meal alone He reported that the cows seemed contented after the first few days but ceased to ruminate At the Utah Experiment Station,* sheep and 2-year-old steers were successful fed on grain alone The sheep were fed for almost 6 months, and the steers for almost 8 months

A later study at the California Experiment Station † shows that dairy animals can be grown to normal size when fed a ration devoid of roughage but supplied with vitamin A Increase in body weight and milk production after first calving were subnormal because of insufficient nutrients The appetites of the animals were excellent, but it was necessary to limit the ration in an effort to avoid serious bloat. The reproduction functions of the animals were normal, some producing as many as three calves without breeding trouble

Seventeen lactations, more than 293 days in length, have averaged 6488 pounds of milk testing 3 19 per cent fat. The lowest production was 4460 pounds of milk, and the highest 9788 pounds The cows ruminated at regular intervals, and the efficiency of digestion was found to be similar to that of animals receiving roughage With the exception of bloat, no unusual symptoms were noted.

* *Utah Exp Sta Bul* 21

† *Hoards Dairyman*, 82 165

For some reason not yet fully explained, calves cannot successfully be grown when their ration is devoid of roughage. The California Station was able to grow calves to maturity by feeding them cod-liver oil and the ash from alfalfa hay, and also calcium carbonate and cod-liver oil. Other investigators have not been

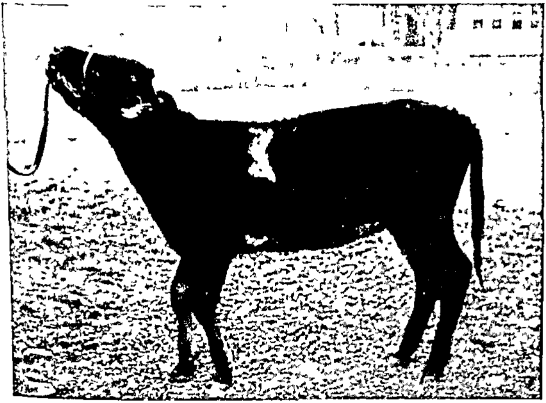

FIG 18. Calf 4 months of age that has been deprived of roughage

so successful. Calves fed milk and grain, or either one alone, develop normally for several months, and then gradually develop anorexia, lose weight, and eventually die. The blood of such animals shows low hemoglobin values, and general evidence of anemia also develops. This, however, can be prevented by the addition of iron and copper to the ration. Often, tetany occurs with calves fed such rations. It has been shown that this is due to low blood magnesium. The Missouri Experiment Station,* however, fed a group of calves on whole milk supplemented with iron, copper, magnesium, and cod-liver oil with the result that they died when about 12 to 13 months of age.

* *Mo. Agr. Exp. Sta. Res. Bul.* 245

Although these studies are of experimental interest, the question whether or not the animal could subsist upon grain alone is not so important as the economy of the practice At ordinary prices of concentrates and hays, it is usually economical to feed roughages freely, at least to the medium producing cows

FEEDING ROUGHAGES ALONE

Dry cows can be maintained successfully on roughage alone, but when cows are producing milk, such a ration is not high enough in net energy to give maximum production

In a trial at the New Jersey Experiment Station * a ration consisting of 35 pounds of corn silage and 17½ pounds of alfalfa hay was compared with one consisting of about 9 pounds of concentrates fed with corn silage and corn stover The latter ration produced 20 per cent more milk than the one without any concentrates

In the irrigated alfalfa districts of the West, alfalfa is often the sole feed of dairy cattle Although highest production cannot be expected with a ration such as this, yet sometimes the increase in production due to the feeding of concentrates may not be sufficient to pay for the extra feed Under such circumstances it may not be economical to feed grain Fairly high production is sometimes obtained when cows are fed roughages alone but usually the production is not so heavy as when they are fed a grain ration Several experiments † have been conducted which show the difference in production the results of which are shown in Table XVIII

Even though the production is much less when the ration consists of roughage alone than when a full grain ration is fed, under certain conditions it may not be profitable to feed the grain

FEEDING FROM RESTRICTED SOURCES

In extensive studies at the Wisconsin Experiment Station ‡ the physiological value of rations from restricted sources for dairy

* N J Exp Sta Bul. 204

† U.S D.A. Rept and Nev Agr Exp Sta Bul. 140

‡ Wisc Res Bul 17 and Wisc Res Bul 49

TABLE XVIII

AVERAGE MILK AND BUTTERFAT PRODUCTION OF COWS FED ROUGHAGES ALONE AS COMPARED WITH THOSE FED ROUGHAGE WITH A GRAIN RATION

Station	Average Yearly Milk Production				Percentage of Difference	
	Roughage Alone		Full Grain			
	Milk, pounds	Fat, pounds	Milk, pounds	Fat, pounds	Milk	Fat
Montana	13,657	478	17,852	620	30 7	29 7
Nevada	8,090	283	9,498	331	17 4	16 9
U S D A	11,375	402	18,009	621	58 3	54 5

cows was investigated One lot of heifers were fed a ration consisting of feeds entirely from the corn plant, another from the oat plant, a third from the wheat plant These rations were comparably balanced in regard to the supply of digestible organic nutrients All the heifers grew fairly well, but those fed the oat and wheat rations failed to give birth to normal young Most of them aborted, and the calves were born dead or very weak The calves from cows fed the corn ration, however, were strong and vigorous Further investigations showed that the wheat and oat rations were lacking in a complete mineral mixture When calcium was added to the ration the calves of the cows fed on the oats ration were normal, although with the wheat plant this was not entirely successful When alfalfa hay was added to the wheat ration in place of the wheat straw, the results were good for a while Growth was normal and reproduction also was normal in the first gestation period, but weakness appeared in the second The alfalfa introduced a better salt mixture, a little different protein mixture, and a more plentiful supply of vitamins

FEEDING BY MEANS OF A SELF FEEDER

When dairy animals are fed by means of a self feeder, in which grain or roughage and grain are put before them so that they have access to them at all times, the animals are very extravagant in the amounts they consume They consume much more feed than they require for maintenance and milk production They not only eat more grain and less roughage, but if given a free choice of concentrates they consume an unduly large amount of protein. Free-choice feeding does not cause cows to balance their nutrients, minerals, or vitamins by instinct They tend to become overweight and are not appreciably more productive The health of the animals is not affected, provided that they are gradually accustomed to the method

Growing animals consume a much larger proportion of grain than hay, to such an extent that they sometimes suffer from a lack of vitamins and develop typical vitamin-deficiency symptoms

Workers at Oklahoma and Texas Stations * successfully regulated the consumption of cottonseed meal by beef cows that were self fed by using a salt cottonseed meal mixture, composed of one third salt and two thirds cottonseed In this proportion the cows consumed an average of 2.7 pounds of cottonseed meal daily

FEEDING EXCESSIVE AMOUNTS OF COTTONSEED MEAL

Cottonseed meal contains a poisonous substance called gossypol which is said to vary with the climate and soil upon which the cotton is grown In preparing cottonseed meal the seeds are heated and the oil pressed out of them In this process some of the gossypol is destroyed or changed chemically so that the meal is less toxic than the seed This gossypol is said to be harmful to livestock, causing what is known as cottonseed meal injury It has been recommended that only a limited amount of cotton seed meal be fed to dairy animals This cottonseed injury is char

* J Am Sci 10 1058 and 1060

acterized by blindness, weakness, abortion with dead or weak calves, and eventual death.

Experiments have shown,* however, that such trouble does not occur when cottonseed meal is fed in addition to a good roughage. The same trouble has been experienced when animals were fed linseed-oil meal, peanut meal, and soybean meal, with a poor roughage It would seem, therefore, that cottonseed-meal injury in dairy cattle was caused, not by the cottonseed meal itself, but by the lack of some substance carried by good-quality hay. Such roughages supply vitamins, especially vitamin A, and calcium, which is lacking in the cottonseed meal and other feeds. There seems to be no danger in feeding large amounts of cottonseed meal to dairy cows or to heifers if it is fed with a good-quality roughage The heavy feeding of cottonseed meal † does not increase the susceptibility of heavy milk cows to udder infection, even when fed in large amounts with alfalfa hay.

FEEDS AND FEEDING METHODS AFFECTING FAT TEST

It has been found ‡ that cows fed only a small amount of ground hay plus liberal amounts of grain decreased in butterfat test as much as 60 per cent Cows fed silage § and finely ground hay in usual amounts did not change in their butterfat test In another study ¶ cows were limited to 3 pounds of hay daily with as much concentrates as they would eat After 2 weeks, the butterfat test had dropped 1 to 2 per cent and remained at that low level as long as the cows remained on this diet The cows on normal roughage feeding had rumen fatty acids in the proportion of 65 per cent acetic, 20 per cent propionic, and 15 per cent butyric, whereas with the low roughage ration, the low fat test was accompanied by a low per cent of acetic and a high per cent of propionic, with the butyric remaining about the same Two

* *N C Tech Bul* 39 and *J Dairy Sci*, 13 478
† *U S D A Tech Bul* 473
‡ *Proc Am Soc Animal Production*, p 40 (1938), *J Dairy Sci*, 28 147
§ *J Dairy Sci*, 22 799
¶ *J Dairy Sci*, 34 493

Florida dairymen * had difficulty with low butterfat test Investigation revealed that they were feeding bulky concentrates and citrus pulp for roughage along with mixed concentrates fed heavily The feeding of baled hay, silage, or providing adequate pasture appeared to alleviate the subnormal butterfat tests

Cod liver oil † given to milking cows in doses of 30 milliliters or more daily will reduce the butterfat test Shark and salmon-liver oil do not depress the butterfat test

Influence of Galactogogues on the Fat Percentage. Many people believe that it is possible to increase the percentage of fat in the milk of a cow by feeding certain galactogogues Several experiments have been conducted to determine the effect of certain galactogogues upon the yield of milk and the percentage of fat Table XIX has been taken from the results of some work done at the Pennsylvania State College ‡

TABLE XIX

EFFECT OF VARIOUS GALACTOGOGUES ON MILK YIELD AND PERCENTAGE OF FAT

The Kind of Galactogogue	Number of Trials	Number Increased in Milk Yield	Number Decreased in Milk Yield	Number Increased in Fat Percentage	Number Decreased in Fat Percentage
Sodium bicarbonate	10	10	0	5	5
Gentian	10	5	5	5	5
Ginger	10	3	7	10	0
Nux vomica	9	4	5	3	6
Pilocarpine hydrochlor (injected)	6	2	4	3	3
Malt extract	10	7	3	5	5
Alcohol (external to udder)	6	2	4	3	3

All ten cows to which sodium bicarbonate was fed showed a slight increase in milk production, but the tests were not re

* *Proc Sou Agr Workers* p. 77 (1949)

† *Secretion of Milk*, Espe

‡ *Pa Exp Sta Rept* 1915–1916

peated a sufficient number of times to determine that these slight increases were not due to natural causes In all the cows which were fed ginger, in ounce doses twice a day, there was a slight increase in the percentage of fat in the milk, but in most of them also a slight decrease in the milk yield, so that the total fat was not increased The other drugs did not seem to have very much effect on either the milk yield or the percentage of fat in the milk

At the Iowa Experiment Station * it was found that alcohol, castor oil, Epsom salts, pilocarpine, and aloes had no effect upon the milk yield Hayes and Thomas † found that air-slaked lime had a beneficial effect upon the milk flow None of the drugs which they used seemed to have any effect in increasing the percentage of butterfat

FEEDING OF MISCELLANEOUS FEEDS AND SUBSTANCES

The feeding of large quantities of fat, ‡ more than 2 pounds per day, to dairy cows will cause digestive disturbances and bring about decreased production

Soybeans contain the enzyme urease When soybeans are processed for oil, the soybean oil meal is usually heated sufficiently to destroy this enzyme Occasionally, some of the enzyme by passes or endures the process When ground, raw soybeans or soybean oil meal containing urease is mixed in a feed containing urea, the urease liberates ammonia from the urea This makes an unpalatable feed which cows do not like and usually will not willingly eat

REFERENCES FOR FURTHER STUDY

1 Fraser and Hayden Balanced and Unbalanced Rations for Dairy Cattle, *Ill Exp Sta Bul* 159 (1912)

2 Elliott and Holdaway, The Effects of High Protein and High Energy Rations in Feeding Dairy Cows, *Va Exp Sta Tech Bul* 12 (1917)

* *J Dairy Sci*, 4 74

† *J Agr Research*, 19 123

‡ *Secretion of Milk*, Espe

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* *J Dairy Sci*, 4 74
† *J Agr Research* 19 123
‡ *Secretion of Milk*, Espe

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4 Converse and Meigs Some Disasters in Reproduction and Growth Caused by Low Quality Hay, *Am Soc Animal Production* (January, 1932)
5 Mead and Regan, Deficiencies in Rations Devoid of Roughage for Calves I The Effect of the Addition of Cod Liver Oil and Alfalfa Ash, *J Dairy Sci*, 14 283 (1931)
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8 Halverson and Sherwood, Investigations in the Feeding of Cottonseed Meal to Cattle, *N C Exp Sta Tech Bul* 39 (1930)
9 Espe and Cannon, Influence of the Physical Character of the Roughage on the Per Cent of Fat Secreted in the Milk, *J Dairy Sci*, 22 799
10 Nelson and others Salt as a Means of Regulating Consumption of Cottonseed Meal by Beef Cattle, *J Animal Sci*, 10 1060

13

Making and Feeding Silage

For a great many years the advantage of preserving green crops for winter feeding has been recognized. As early as 1786,* history records that the Italians preserved green crops for their animals by storing them in pits under the ground. The French and English are known to have stored green crops a century and a half ago. We are not quite certain who should be given credit for the first silo in the United States, but it is probably Fred L. Hatch, who built one on his farm in 1873. Nevertheless, farmers were slow to follow his example, and silos have been used extensively only since about 1900. They are now to be found in all sections of the country, especially where dairying plays any large part in the farming industry. The use of the silo to preserve corn, grasses, legumes, and other crops for feed for dairy cows is now a very common practice. It is an important part of the equipment of a profitable dairy farm in many sections of the country. In some of the southern states cattle are pastured during most of the year, and consequently silage is not fed so extensively as in areas where heavy winter feeding is practiced.

ADVANTAGES OF THE SILO

The silo is used and silage is fed on most dairy farms in the United States. This widespread use is the result of the following advantages:

1. The silo offers the one means of taking the entire forage plant from the field and preserving it in a succulent form. The crop can be harvested and stored at the time in its development when it has the greatest milk producing value.

* U.S.D.A. *Farmers' Bul.* 32.

2 More feed nutrients can be grown on an acre of crop used for silage than an acre used for most other crops This is shown in Table XX, which gives the estimated crop yields, digestible

TABLE XX

ESTIMATED CROP YIELD, DIGESTIBLE NUTRIENTS, AND MILK PRODUCTION PER ACRE

Crop	Pounds per Acre	Digestible Protein, pounds	Total Digestible Nutrients, pounds	4 Per Cent Milk, pounds
Corn silage	12,000	180	2472	3862
Alfalfa hay	4,000	424	2012	3142
Corn, ear and stover	3,850	135	1960	3062
Timothy hay	2,000	58	938	1462
Soybean hay	3,000	333	1518	2370

nutrients, and milk production per acre of various crops

It can be seen from this table that corn silage furnishes more nutrients per acre than any other crop Alfalfa and some of the other legumes rank high in this respect and produce more digestible protein than corn

3 Less waste results when crops are put into the silo than when they are handled in the dry state More than one third of the total food material in the corn plant is found in the stover When corn is husked in the field and the stover is fed, considerable loss always results Table XXI from the Pennsylvania Experiment Station* gives the relative amount of digestible matter found in the ears and stover of an acre of corn

TABLE XXI

COMPARISON OF DIGESTIBLE MATTER FOUND IN THE EARS AND STOVER OF AN ACRE OF CORN

Constituents	Ears	Stover	Total Crop
Protein pounds	244	83	327
Carbohydrates, pounds	2301	1473	3774
Fat, pounds	125	22	147
Total	2670	1578	4248

* U S D A Farmers Bul 578

Even when corn is husked and carefully shocked, much of the food value in the stalk is lost. In tests made by the Colorado Experiment Station, the losses due to curing corn in the field were considerable. Table XXII shows these losses under different ways of handling.

TABLE XXII

LOSSES DURING CURING OF CORN UNDER DIFFERENT METHODS

	Large Shock		Small Shock		On the Ground	
	Total Weight, pounds	Dry Matter, pounds	Total Weight pounds	Dry Matter, pounds	Total Weight pounds	Dry Matter, pounds
When shocked	952	217	294	77	186	42
After curing	258	150	64	44	33	19
Loss in weight	694	67	230	33	153	23
Per cent loss	73	31	78	43	82	55

When the corn is put into the silo, all the food nutrients goes with it. The losses in the silo due to fermentation, though considerable, are much lower than those that occur when the fodder or hay crop is exposed in the field. It was found at the Wisconsin Experiment Station * that the losses in the silo due to fermentation and to spoilage on top and sides and the losses of the juices averaged about 9.1 per cent. If crops are made into hay the losses because of unfavorable weather conditions are often very heavy.

The Bureau of Dairy Industry, United States Department of Agriculture,† reports the loss of nutrients in alfalfa from the time it was cut until it was fed in the manger. In these experiments they compared the loss under three systems of storage, as silage, as barn cured hay, and as field cured hay without rain damage. The silage method conserved a higher percentage of dry matter,

* *Wisc. Exp. Sta. Bul.* 59.

† BDI INF-117 (1951).

protein, and carotene than either of the other two methods The silage also produced more milk than did the hays, and the milk was considerably higher in its carotene content. The relative efficiency of these three methods is shown in Table XXIII.

TABLE XXIII

PER CENT OF DRY MATTER, PROTEIN, AND CAROTENE PRESERVED, AND RELATIVE AMOUNT OF MILK PRODUCED FROM ALFALFA STORED BY THREE METHODS

	Dry Matter Preserved, per cent	Protein Preserved, per cent	Carotene Preserved, per cent	Milk Yield per Acre of Forage, per cent
Crop as cut	100	100	100	
Wilted silage	84	84	28	112
Barn-cured hay	81	76	7 5	108
Field-cured hay, (no rain)	75	69	3 0	100

4. The crop can be harvested and stored as silage more cheaply, more quickly, and with less labor than in other methods of harvesting This is because most of the work is done with machinery and the crop is handled but once The field chopper, automatic unloader, and forage blower have practically eliminated the need for handling the silage crop by hand at any point from the standing crop to the stored silage

5 Silage requires less space for storage A ton of silage requires from 40 to 50 cubic feet of space, whereas a ton of loose hay will require 8 to 10 times this space, and baled hay, 3 to 4 times as much space One ton of hay has a feeding value about equal to 3 tons of silage

6 Feed stored as silage is not subject to fire hazards as is hay

7 Practically any green forage crop is suitable for ensiling. Weedy crops and crops with coarse stalks can often be used with good results when put into the silo

8 In many areas of the United States it is difficult to cure hay satisfactorily because of the weather conditions The use of the silo makes the saving of hay crops possible, even under unfavorable hay making weather

9. Silage provides a succulent feed available at all times of the year. A succulent feed is necessary for the most economical production of milk, and the silage provides it for winter feeding better than other feeds. The carotene is better preserved and the silage makes a very palatable feed, which has a beneficial effect upon the digestive system of the cow.

CHEMICAL CHANGES IN SILAGE

When the green chopped forage is first stored in a compact mass in a silo, the living plant cells continue to respire, thus rapidly using up the oxygen in the trapped air and giving off carbon dioxide. In about 4 or 5 hours the free oxygen is all used up but the carbon dioxide increases rapidly for about 48 hours, when it comprises from 60 to 70 per cent of the silo gases. Subsequent to this it begins to decrease. After the oxygen is used up molds do not develop, since they are unable to grow in the absence of oxygen.

Temperature Increases. If the air is excluded, the increase in temperature is not great, it will be about 80° to 85°F. near the bottom and about 100°F. or a little more near the top. The temperature continues to increase for about 15 days and then gradually decreases. If air gets into the silage, the temperature may rise to 130°F., but when the silage is properly packed, this increase will occur only near the surface or where the air can reach it. The heat is caused by bacterial fermentation.

Bacteria Increase. The plant forage carries with it a large number of bacteria. The conditions for growth found in silage (proper temperature, food, and moisture) are excellent, especially for the lactic acid bacteria, and their numbers increase very rapidly, frequently to hundreds or thousands of millions per cubic centimeter of the juice. These bacteria or enzymes produced by them, and enzymes from the cut plant material, attack the sugars and other food material, breaking them down into organic acids, principally lactic, with some acetic and small amounts of other acids, and also some ethyl alcohol. It has been found that besides the sugars, 25 per cent of the pentosans and 25 per cent of the starch contained in the forage are changed as a result of 4 months ensiling. Much of it is changed to organic acids

and some of it is used for food for the bacteria and is built up into compounds in their bodies In this process, some of the proteins of the green forage are also broken down or digested and some are used by the bacteria for their growth, much as occurs in the paunch of the cow

ACIDITY STOPS BACTERIAL GROWTH When the acid in the silage has increased to a certain degree, bacteria cease to multiply and, hence the action of the enzymes stops, with the result that no more acid is developed, putrefaction ceases, and if air does not gain entrance, the silage will keep for long periods with but very little change The amount of acid that will develop depends largely on the kind of crop, especially as to its sugar content If the forage does not contain enough sugar, sufficient acid may not be produced to prevent spoiling of the silage which often occurs when legumes and certain other crops are made into silage, unless special methods are used The lactic acid content of the nonvolatile acid at various stages of fermentation is shown in Table XXIV, from results obtained at the Wisconsin Experiment Station *

TABLE XXIV

LACTIC ACID CONTENT OF THE NONVOLATILE ACID AT VARIOUS STAGES OF FERMENTATION

(Calculated for 100 Grams of Dry Silage)

Age of Silage days	Total Nonvolatile Acid grams	Lactic Acid grams	Nonlactic Acid grams
0	2 025	0 199	1 826
1	2 195	0 514	1 681
3	3 579	1 868	1 711
30	6 818	5 290	1 528
132	7 986	6 117	1 869

Causes of Poor Silage Good silage should have a mild, pleasant aroma an acid taste, and a slightly greenish color It should be free from sliminess and mold and have sufficient acid to prevent further action of microorganisms Although ordinary good conditions will produce good silage, sometimes, for various rea

* *Wisc Res Bul* 61 (1925)

sons, the silage may not keep satisfactorily, with its resulting loss Hay crop silage is more difficult to preserve than corn or sorghum silage The causes of poor silages can be listed as follows

1 Not Enough Acid When the forage which is ensiled does not develop sufficient acid to stop the fermentation, undesirable bacteria cause putrefaction or rotting Such bacteria produce enzymes that break down some of the protein, causing an off flavor and slimy silage

2 Too Much Acid When forage crops with an exceptionally high sugar content, such as immature corn or sorghum is used, the acid may be so high that a sour, unpalatable silage may result Such silage is not only unpalatable, but when fed in large quantity causes cattle to scour

3 Not Enough Moisture When not enough moisture is in the forage, the silage will not pack well and more air than the bacteria can use up will be left in the silage This will result in a moldy silage Sometimes, when the forage is slightly too dry, air pockets are left through the silage, which will result in occasional batches of mold throughout the silo, and occasionally air will be left in forage with hollow stems, causing spoilage of the silage Such crop should be packed with especial care so that all air will be pressed out

4 Too Much Moisture When the forage contains too much moisture, the silage is likely to be too sour, and often at the bottom of the silo will be several feet of sour, soggy, unpalatable silage that the cattle will not eat Hay crop silages, especially those made of legumes, may not keep satisfactorily if the moisture is too high Wilting the silage to reduce the moisture content often will result in good silage

Methods Used to Insure Good Hay Crop Silages Little trouble is experienced in the preservation of corn or sorghum silage when they are ensiled at proper time, since they contain an ample supply of sugar, which is quickly converted into lactic acid Such is not true with the grasses and legumes, which when used for silage, are usually referred to as hay crop silages The chief reasons why special methods are used to insure proper keeping of these crops are as follows

1 They may not contain enough sugar to produce sufficient acid to keep it from spoiling or from having a strong undesirable odor

2 The legumes are more alkaline than corn or sorghum and neutralize some of the acid that is produced

3 The forage often is high in moisture content.

Special methods consist of lowering the moisture content, adding additional acid, or adding material from which acid can be made, such as feeds high in sugar or starches The common methods are as follows

1 ADDITION OF ACIDS The first method proposed for the preservation of hay crop silage was the addition of dilute mineral acids This patented method, using dilute HCl and H_2SO_4 is known as the A I V method after its originator, A I Virtanen, of Finland, and is used extensively in Finland, Sweden, and other northern European countries It has never gained great popularity in the United States, however, partly because of its destructive action on silo walls and silo filling equipment

In the normal method of silage making, there is considerable destruction of food nutrients In the A.I V method this is avoided, by putting into the silage various mixtures of mineral acids so that the *p*H of the resulting silage shall be between 3 6 and 4 In this method, often referred to as the cold process, only a limited amount of fermentation takes place, but the crop is preserved satisfactorily and much of the carotene content of the green crop is retained

In this country, phosphoric acid has been used much more widely than the other acids, since it does not have as great a destructive action as the stronger acids, and it increases the phosphorus content and residual manurial value of the silage It will preserve the silage as well as the stronger acids

In feeding this silage, it is recommended that about 2 ounces per head per day of finely ground limestone or other calcium carbonate compounds be fed in order to neutralize any excess of acid present.

2. ADDITION OF MOLASSES When the forage is low in sugar, additional sugar may be added so that the bacteria will have ample food and the fermentation will proceed normally Molasses is the preservative that is most commonly used Black

strap, beet, corn, and citrus molasses are all suitable Commercial products containing molasses absorbed on ground grains and various by-products are also satisfactory preservatives Molasses improves the quality of these hay-crop silages both in quality and palatability. It is estimated that about 75 per cent of the food value of the molasses will remain in the silage

3 Addition of Ground Grain Ground grains such as corn meal, corn-and cob meal, ground barley, ground wheat, or other high carbohydrate grains may be added to the hay-crop silages to preserve them Such additions increase the percentage of dry matter in the silage, will supply starch that may be converted into acids, and add to the palatability of the silage Much of the food value of these grains will be retained in the silage

4 Wilting the Crop The wilting of the forage for 2 or 3 hours in sunshine before ensiling will usually result in a better silage than when it is not wilted The wilting will reduce the water content so that the sugar content per pound of forage is increased The amount of moisture in fresh forage cut at the proper time for silage is usually high, around 75 per cent or more This should be reduced to between 60 and 70 per cent (optimum, 65 to 68 per cent) If below 60 per cent moisture, there is not sufficient moisture and the silage may mold, if over 70 per cent, the silage will not go through the normal fermentation Usually, if the moisture is over 70 per cent, a considerable amount of juice will run out, carrying with it some nutrients and causing a foul odor around the silo The juice from the silage has a destructive action on the walls of silos The Dairy Division, United States Department of Agriculture,* reports results of various combinations of acidity and moisture, for example, high moisture along with low acidity favors the production of butyric acid and the breakdown of proteins This gives an off flavored silage with an objectionable odor On the other hand, high moisture with high acidity, low moisture and low acidity, or low moisture with high acidity in silages may not cause objectionable odors or flavors

5 Miscellaneous Preservatives Several other kinds of preservatives for the keeping of hay crop silages have been used successfully Good results have been reported from the use of

* *U S D A Leaflet* No 238 and *Farmers' Bul* 578

liquid sulfur dioxide * The addition of sodium bisulfite † at the rate of 8 pounds per ton of the silage crop produced a very satisfactory silage Dried whey has been used to supply fermentable carbohydrates Chopped hays, straws, and stover have been mixed with wet forage in order to reduce the moisture content to the desired level

The use of bacterial cultures, the addition of urea, and the addition of 15 to 40 pounds of salt per ton have been tried but have not given satisfactory results

6 MIXING HAY CROPS WITH CORN OR SORGHUM FORAGE One way to insure the keeping of hay crop silage is to mix the crop with corn or sorghum forage These contain sugar sufficient to induce the normal fermentation Such crops as soybeans or alfalfa can be mixed with corn or sorghum Equal parts of corn forage and the legume will be satisfactory, but sorghum that contains more sugar than corn can be used in the proportion of 3 parts of legume to 1 of sorghum

CROPS FOR SILAGE

A great many different crops are being used for silage Practically any forage crop that is desirable for pasture, hay, or fodder will make a desirable silage In fact, some crops that are not desirable as pasture or cured feed have been reported used for silage with satisfactory results Some plants that are bitter or produce off flavor in milk if fed green or cured often appear to lose these qualities during the ensiling process Most weed seeds are destroyed by ensiling. To make good silage, however, good crops cut at the proper stage and put into the silo without losing a part of their feeding value by leaching or by loss of leaves must be used

Corn. Corn is a standard and popular crop for silage in most dairy sections, since its yield in tons of forage per acre is high Since the corn plant at time of ensiling is high in available sugars, so that normal fermentation takes place without the addition of any preservatives, the making of silage from corn is easier

* *J Dairy Sci* 34 6, p 493 (1951)

† *J Dairy Sci*, 36 6 p 602–3 (1953)

than from grasses and legumes To make the best silage, the dry matter should not be lower than 27 or 28 per cent.

VARIETIES The best silage corn varieties are changing fast with the development of hybrid varieties The work of various experiment stations indicates that the variety that will yield the greatest amount of dry matter and mature to the late dough stage during a normal season is the best to grow Silage corn is planted thicker than corn for grain, however, it should not be planted so thick that it will not develop ears Varieties with good root systems and that will stand up well are especially necessary in view of present-day machinery

YIELD PER ACRE The amount of corn silage that can be grown on an acre of land varies with the soil, climate, care, and the variety of corn From 6 to 20 tons can be grown to an acre For land yielding 50 to 75 bushels of corn per acre the silage yield would be about 10 to 15 tons of silage

TIME TO HARVEST Several factors enter into the proper time to harvest corn for silage. Table XXV, based on work done at

TABLE XXV

CHEMICAL CHANGES DURING THE GROWTH OF THE CORN PLANT

(Yield per Acre)

	Stage of Growth				
	Tasseled, July 30, pounds	Silked, Aug 9, pounds	Milk, Aug 21, pounds	Glazed, Sept 7, pounds	Ripe, Sept 23 pounds
Total yield	18,045	25,745	32,600	32,295	28,460
Water	16,426	22,666	27,957	25,093	20 542
Dry matter	1,619	3,078	4,643	7,202	7 918
Ash	138 91	201 30	232 15	302 48	364 23
Albuminoids	239 77	436 76	478 69	643 86	677 78
Crude fiber	514 19	872 93	1,261 97	1,755 85	1,734 04
Nitrogen free extract	653 91	1,339 26	2,441 29	4,239 82	4 827 60
Fat	72 20	167 75	228 90	259 99	314 34

the New York Experiment Station,* gives the composition of the corn plant in its different stages It is best to harvest the corn in

* N Y *Exp Sta 8th Ann Rept*

the advanced glazed stage, and if a dent variety, when the dent is well developed and when most of the leaves are still green Where there is a large volume to get in, it is necessary to begin ensiling a little early to be able to get the last part of the crop in before it is too ripe For the dairy farm it is wise to cut the corn when it is a little green rather than risk its being frosted or becoming too ripe, because of the effect on the carotene content. Experiments carried on by the United States Department of Agriculture have shown that corn ensiled when it was 90 to 100 per cent green resulted in a silage containing 111 to 156 parts of carotene per million When the corn was ensiled at the time when only 40 to 60 per cent of the leaves were green, the resulting silage contained 35 parts of carotene per million When it was ensiled after a slight frost, practically no carotene (4 p p m) was present in the silage On the other hand, it is not advisable to put the corn into the silo when it is too green as there is always considerable leakage of moisture, which carries with it some of the food nutrients It may also become acid if ensiled too green and may not be as palatable as more mature corn It may be laxative when fed in large quantities

It is not wise to let the corn mature to the point of dryness, however, even though it is mature and dry, if sufficient water is added it can be preserved satisfactorily but will be low in carotene

Corn Stover. If, as occasionally happens sufficient space is not available at silo filling time for all the corn crop that may be desirable to put in the silo, the corn stover may be put in later Stover silage has the advantage of being more palatable than dry stover, it prevents the loss of much of the stover and is much more convenient to feed The stalks of the stover are put in the silo in the same way as the green corn, but in order to preserve it large quantities of water must be added The amount of water added must be at least equal in weight to the stover, and can be added by turning a hose into the blower or by running water directly into the silo It should be borne in mind that since the ears have been removed it is not equal to corn silage in food nutrients

Sunflowers Sunflowers have been used successfully for silage in regions of short growing seasons and cool nights where corn

cannot be grown so successfully. In such regions their yield is a little higher than that of corn but they are not quite so high in nutritive value nor are they as palatable

They are planted in rows and can be harvested in the same way as corn. Table XXVI from the West Virginia Experiment Station [*] gives the analysis of sunflowers at different stages.

TABLE XXVI

ANALYSIS OF SUNFLOWERS AT DIFFERENT STAGES OF MATURITY

Stage Analyzed	Moisture, per cent	Ash, per cent	Protein, per cent	Fat, per cent	Fiber, per cent	Carbohydrates, per cent
Bud stage	80 75	1 53	1 41	0 55	5 48	15 76
Full blossom	86 69	1 59	1 21	0 50	3 90	10 01
Petals dropping	83 97	1 78	1 12	0 66	5 56	12 47
Dough stage	83 34	1 69	1 10	1 06	4 96	12 81
Mature	84 26	1 74	1 61	1 36	4 75	11 03
Silage	76 20	2 33	1 86	1 18	7 48	18 43

At the West Virginia Station [†] the average yield for 3 years was 13 85 tons of green material and 2 08 tons of air-dry material per acre, as compared with 11 79 tons green material and 2 91 tons of air dry material per acre for a large variety of corn and 8 98 tons of green material and 2 57 tons of air-dry material per acre for a small variety. There is no advantage in growing sunflowers for silage where corn will produce good yields

Sorghum Sorghum makes good silage when put in the silo at the proper time The sweet sorghums are better for silage than the grain sorghum, although the taller grain sorghums, especially kafir, are used successfully Sorghum yields better than corn in the deep South and in the drier parts of the Mid-West Sorghum silage is not as efficient as corn silage for the production of milk It should be cut in the dough stage If it is cut too early the silage will be sour and unpalatable On the other hand, it should not be cut too late, as many of the matured grains will pass through the cow undigested

Grasses and Legumes. Grasses and legumes will be considered together here under the term hay crop silage, which is used to-

[*] *W Va Exp Sta Circ* 32
[†] *W Va Exp Sta Bul* 204

day to include silage made from grasses, legumes, small grains, or from any combination of these crops Methods used in the proper ensiling of these crops were discussed in the earlier part of this chapter

Most of the research work on grass silage has been done since 1930, and before that very little had been used An increase in the growing of grass and legumes and a decrease in land planted to row crops has been fostered by many of the agricultural agencies As a result, there are now many farms and a few large areas that are on a strictly grassland program with hay crop silage playing an important role

CROPS It would be impossible to list all the crops that are suitable for making into hay-crop silage that may be grown within the United States The most important ones are all grasses, alfalfa, red clover, ladino clover, sweet clover, crimson clover, lespedeza, soybeans, cowpeas, peas, pea vine, vetch, wheat, oats, barley, rye, Sudan, excess pasture, and a mixture of any grasses and legumes Many other crops of lesser importance have been successfully used

TIME TO HARVEST The crop material is at its best for ensiling at the same period that it should be cut for hay The best time for cutting grasses is just before heading The legumes are ready when in one tenth bloom, soybeans when the pods have formed and begin to fill, and small grains in the early milk stage At these stages they contain the maximum milk producing nutrients, are lower in undigestible fiber, and are most palatable

COMPOSITION AND FEEDING VALUE The amount of dry matter in hay crop silages depends greatly upon whether and how much the crop has been wilted and also upon the maturity of the crop at time of ensilaging. On the average, silage will contain about one third as much dry matter as does hay, in other words, 3 pounds of silage will on the average equal 1 pound of hay

Hay crop silage is lower in total digestible nutrients and net energy than is good corn silage with the same amount of dry matter, but is higher in protein, minerals, and carotene Because of its higher protein content, less protein is needed in the grain mixture The higher carotene content is valuable in supplying

the needed vitamin A for growth, reproduction, and health, and to insure a milk rich in vitamin A and carotene Hay-crop silage does not contain as much vitamin D as does field-cured hay Green forage plants do not contain vitamin D but do contain its precursor, ergosterol, which may be changed to vitamin D during field curing when the hay is exposed to the sun

Hay crop silage as a rule is not as palatable as corn silage Cows eat it readily after they become accustomed to it, but they do not usually relish it as much as corn silage However, it is an excellent feed Best results are obtained when it is fed in combination with hay rather than as the sole roughage Cows may have difficulty in securing sufficient dry matter for maximum milk production when fed hay crop silage alone It is usually best to feed at least 4 to 6 pounds of hay per day with the silage Even growing heifers will do better when a little hay is given along with the hay crop silage Hay crop silage is an excellent summer supplement Table XXVII gives the composition and other nutrient data * of various feeds

YIELDS The yield per acre of hay-crop silage is not usually as great as that of corn, but if the soil is well fertilized excellent yields may be obtained On some farms grassland farming is being practiced exclusively, with no row crops being grown On many farms where row crops are no longer grown and the fertility of the land as a whole has improved, the total carrying capacity of the farm has increased under the grassland system

The yields of silage for the different crops can be estimated by multiplying the expected yield of hay by 3 If an alfalfa field would produce 4 tons of hay per acre during the year, it should furnish about 12 tons of silage

MISCELLANEOUS FEEDS FOR SILAGE Numerous feed materials are occasionally used for silage with satisfactory results Some of these feeds are apple pomace, cull apples, potatoes, beet pulp, and cannery refuse If too high in moisture, like cull apples and potatoes, for example, they should be put into the silo with dry hay or some material that will absorb the excess moisture

* *U S D.A Farmers' Bul* 578 (1941)

TABLE XXVII

COMPOSITION AND DIGESTIBLE NUTRIENTS OF CERTAIN FORAGES GREEN, AS SILAGE AND DRIED *

Forage Crop	Composition of the Forage: Moisture per cent	Ash per cent	Crude Protein per cent	Ether Extract (Fat) per cent	Crude Fiber per cent	Nitrogen Free Extract (Sugars Starches etc.) per cent	Digestible Crude Protein in the Forage per cent	Total Digestible Nutrients in the Forage per cent	Total Digestible Nutrients in the Dry Matter, per cent
Alfalfa in bloom green	77.2	1.8	3.2	0.6	7.8	9.4	2.4	12.9	56.7
Alfalfa silage	68.9	2.7	5.7	1	8.8	12.9	4	18.8	60.6
Alfalfa hay	7.2	8	15.4	1.6	30.3	37.5	10.8	52.3	56.4
Red clover in bloom green	70.8	2.1	4.4	1.1	8.1	13.5	2.9	19.4	66.4
Red clover silage	72	2.6	4.2	1.2	8.4	11.6	1.3	12.1	43
Red clover hay	7	10	16.1	2.6	23.6	40.7	9.7	40.5	53.2
Soybeans green	73.0	2.0	4	1.1	7.6	10.5	3.2	16	61.1
Soybean silage	75.0	2.6	2.4	0.8	9.6	9	1.6	13.1	53.5
Soybean hay	8.4	8.0	15.8	3.8	21.3	38.8	11.2	55.6	60.7
Timothy in bloom green	61.6	2.1	3.1	1.2	11.8	20.2	1.5	22.9	59.5
Timothy silage	60.8	2.8	4.4	1.4	13	18	2.3	23.8	59.8
Timothy hay	7.1	5.8	7.5	2.9	30.2	46.5	3.5	52.5	56.5
Corn fodder dent green	73.4	1.5	2	0.9	6.7	15.5	1.3	19.3	72.7
Corn silage	70.0	1.4	2.4	0.9	6.9	17.5	1.1	19.8	67.9
Corn fodder dry	11.8	5.8	7.4	2.4	23	43.6	3.4	55.3	62.7
Sorgo, green	77.9	1.3	1.5	1	6.2	12.7	0.6	15.3	67.2
Sorgo silage	74.7	1.4	1.6	1	6.9	14.4	0.4	15.3	60.5
Sorgo fodder dry	11.0	6	5.3	2.4	26	48.7	3.3	58.2	63.8

* Compiled in the Division of Animal Nutrition, Bureau of Animal Industry, U. S. Dept. Agr.

HARVESTING THE SILAGE AND FILLING THE SILO

The past several years have brought about many changes in the equipment for handling the silage crop and in the amount of hand labor required. Present-day silage-making machinery not only requires much less labor but also can eliminate entirely the handling of the crop by hand.

FIG. 19. A field harvester for chopping silage or hay in the field (*V.P.I*).

The Field-Chopper Method. The field-chopper or forage harvester will chop the crop either standing or when it is in the windrow. Corn is usually cut from the row, but hay-crop silage crops can be cut either from the standing crop or from the windrow. The chopper blows the cut material into a truck or trailer. A dump truck may be used or the truck or trailer can be equipped with an automatic unloading device, such as an endless belt of canvas or a false bottom. Either of these will unload by the use of power at the silo. The trucks or trailers are unloaded directly into the hopper of the silage blower or forage elevator which, in turn, blows or elevates the material into the silo. The crop

should be cut into small pieces not over one half inch long, and even one fourth inch is better for hay crops since it will pack better at the shorter length

The Silage Cutter Method On smaller farms, where the investment in machinery must be kept to a minimum, a less mechanized system is used The corn can be cut by a corn harvester or by hand It is then loaded on a wagon or truck and hauled to the silage cutter at the silo Grass crops can be handled with the regular haying equipment to get it to the silage cutter The cutter chops the material and blows it into the silo

Danger of Carbon Dioxide During the fermentation process carbon dioxide is given off This gas is dangerous As this is a heavy gas, it does not pass out if the doors are closed for some distance above the silage Care should be taken, therefore, during the filling period when the machine has not been running for some time, not to enter the silo until the blower has driven off the dangerous gas

Adding Preservatives Preservatives for grasses and legumes may be added in various ways Most silage cutters that are made especially for hay crops have a suction attachment that draws molasses out of a barrel on the ground A small pump may be rigged with a long hose and pump the molasses slightly diluted, into the silo The barrel can be placed on a platform to let the molasses run on to the forage at the cutter Acid should be pumped so as to keep it from contact with the silage equipment.

Corn and cob meal or other ground grains can be added on the green material at the cutter This can be done by hand or with a hopper The amount of preservatives to use is given in Table XXVIII

Wilting To insure the making of good quality hay crop silage without the use of preservatives, the crop may be wilted to reduce the moisture content The length of time required for sufficient wilting depends on the maturity of the crop, the moisture in the soil underneath the crop, the humidity, and the sunshine It may vary from less than an hour to several hours On good drying days most crops will wilt sufficiently in 2 to 3 hours unless the material is especially heavy and green A home made tester has been developed for determining the moisture content

TABLE XXVIII

THE AMOUNT OF PRESERVATIVES RECOMMENDED FOR USE ON VARIOUS CROPS, PER TON OF THE FORAGE

Type of Preservative	Grasses and Cereals, pounds	Mixed Grasses and Legumes, pounds	Alfalfa or Clover, pounds	Soybeans, pounds
Molasses, per ton	40	60	80	100
75 per cent phosphoric acid, per ton	8	10	14	16
Ground grains, per ton	75	100	125	150

of hay crop silage,* but it requires some time to operate and is not generally used

The farmer can learn to tell when the crop has wilted sufficiently, in the same manner that he learns when the crop is dry enough to be put into the barn as hay When the wilted material is twisted with the hands it should show evidence of containing moisture but not show free moisture When the forage is chopped, it can be tested by squeezing it in the hand, if it is too wet it will retain its shape after being released and if too dry it will fall apart at once, but when it is the correct stage it will fall apart slowly

SEALING THE TOP LAYER OF SILAGE

One of the greatest losses of nutrients in silage is in the spoilage on the top of the silo Various means have been used to reduce this loss The last few loads may be of less valuable material, for example, if they are corn, the ears can be removed A few loads of very wet material helps to pack it into a tight mass and exclude most of the air A covering of heavy paper with sawdust or other material blown on top and kept wet will reduce spoilage A plastic silo cap is on the market which covers the top, and then a large tube filled with water is laid around the edge to hold it tightly in place This has proved very successful

* *U S D A Leaflet* 238

Oats or other grains are sometimes sown on top which on growing form a dense mat which helps to keep the air out.

TYPES OF SILOS

Many types of silos and of silo building materials are available most of which will prove satisfactory as far as keeping the silage is concerned The cost and durability of the various kinds differ considerably

Upright Silo The upright silo is the conventional silo It may be constructed from wooden staves monolithic concrete concrete staves tile brick, or metal Most of the tile and part of the concrete staves used are hollow offering the advantage in cold climate of less freezing of the silage With the development of new alloys and materials to coat the inside of metal silos they are becoming quite popular

An airtight silo offers some possibilities of reducing loss by spoilage When it is filled the top is sealed Fermentation uses up the oxygen inside it and replaces it with carbon dioxide No oxygen is left for spoilage It is equipped with a power mechanism for removing the silage from the bottom The inside is coated with glass which is smooth and allows the silage to slide down as silage is removed from the bottom

Temporary silos may be constructed from many materials One type is very commonly made by using snow fence lined with a heavy paper such as Sisal kraft paper These silos are quite satisfactory for temporary use The silage loss is usually greater than with the standard silo This is because their height cannot be greater than their diameter which results in more surface loss

Trench Silo The trench silo has become popular in many sections of the country especially where dairying is new They are inexpensive to construct Silage keeps well in them They are easy to fill The packing may be done with a tractor The use of the trench silo should be increased where the conventional silo is not available This also offers a method of preserving an extra amount of silage during a good crop year and holding it for a poorer crop year

SIZE OF SILOS

The capacity of silos is dependent upon its diameter and height and also upon the kind of forage that is put in, especially as to its moisture content The weight per cubic foot will vary from 30 to 40 pounds for a trench silo and from 45 to 50 pounds for a tall upright silo Table G, in the appendix, prepared by the United States Department of Agriculture,[*] lists the capacity of silos of various diameters and heights, and the weight per cubic foot of settled silage in silos of various heights

The amount of silage needed per cow per year will vary from 2 tons or less to 6 tons or more, depending on the amount of hay and pasture that is available Table XXIX gives the tonnage of silage and the size of silo needed for different size herds when fed at various rates per day [†]

It is important that the diameter of the silo is not more than will permit at least 2 inches of silage to be fed off per day in winter or 3 inches per day in warm weather, otherwise, considerable spoilage will result The diameter of the silo would therefore depend upon the number of cows to be fed from it, the height, and the length of the feeding period

FEEDING THE SILAGE

Silage and other succulent feeds are excellent for dairy cows, especially because of their palatability and slightly laxative effect For these reasons cows will consume large amounts of nutrients without any harmful effects, and will as a consequence produce more milk than when fed feeds less palatable Succulent feeds however, are not absolutely necessary for high production When cows are fed a good legume hay, with some other good hay for variety, and are given access to an abundant supply of water, they will produce just as much milk as when fed silage If the roughage is not of the best quality, however, cows will usually milk better when silage is included in the ration

[*] *U S D A Circ* 603

[†] *U S D A Farmers' Bul* 578

TABLE XXIX

SIZE OF SILO REQUIRED FOR DIFFERENT-SIZED HERDS WHEN FED AT VARIOUS RATES

Number of Animals	Quantity Fed per Animal Daily, pounds	For a Winter Feeding Period of 200 Days: Total Amount Needed, tons	For a Winter Feeding Period of 200 Days: Diameter and Height of Silo, inside measurements, feet	For a Summer Feeding Period of 100 Days: Total Amount Needed, tons	For a Summer Feeding Period of 100 Days: Diameter and Height of Silo, inside measurements, feet
5	30	15	8 by 18		
5	40	20	8 by 22		
5	50	25	8 by 26		
10	20	20	8 by 22	10	*
10	30	30	10 by 22	15	8 by 18 †
10	40	40	10 by 28	20	8 by 22 †
10	50	50	10 by 32 12 by 24	25	8 by 26
20	20	40	10 by 28	20	8 by 22 †
20	30	60	12 by 28	30	10 by 22 †
20	40	80	12 by 36 14 by 28	40	10 by 28
20	50	100	14 by 34	50	10 by 32 12 by 24
30	20	60	12 by 28	30	10 by 22 †
30	30	90	14 by 30	45	10 by 30
30	40	120	14 by 40 16 by 32	60	12 by 28
30	50	150	16 by 38	75	12 by 34
40	20	80	12 by 36 14 by 28	40	10 by 28
40	30	120	14 by 40 16 by 32	60	12 by 28
40	40	160	16 by 40	80	12 by 36 14 by 28
40	50	200	16 by 48 18 by 40	100	14 by 34
50	20	100	14 by 34	50	10 by 32 12 by 24
50	30	150	16 by 38	75	12 by 34
50	40	200	16 by 48 18 by 40	100	14 by 34
50	50	250	18 by 48	125	14 by 40 16 by 32

* A silo that would hold only 10 tons or less would be too small to be practicable.

† Too shallow to permit 3 inches to be removed daily. Removal of less than 3 inches daily is not practicable for summer feeding.

The amount of silage fed to cows depends upon the amount available and also upon the size of the cow, usually it ranges between 20 and 40 pounds. The general rule is to feed it at the rate of 3 pounds of silage and 1½ pounds of hay for each 100 pounds of live weight. Experiments have shown that 3 pounds of silage can be substituted for 1 pound of hay and fed with about equal results. If a limited amount of silage is available, the quantity can be cut in half and the hay increased without affecting milk production. Silage can be fed as the sole roughage, provided that sufficient protein and minerals are given in the grain mixture. Cows will consume up to 6 or 8 pounds per 100 pounds live weight when fed in this way.

CONSTRUCTION OF SILOS

One of the most common mistakes in the building of silos is to give them overlarge diameters, which make it impossible to feed the silage fast enough to keep it from spoiling. Each day, 2 to 3 inches should be removed from the surface of the whole silo in order to preserve the silage. A further advantage of a silo with a small diameter and a greater height is that the silage will be more compressed and less air will be admitted. If small quantities of silage are needed for supplementary feeding, as, for instance, for late summer feeding, it is well to provide a separate and smaller silo.

Walls. In the building of a silo, the first essential is a tight wall that will exclude air and moisture and at the same time not absorb moisture from the silage. When the moisture is taken up by the wall the absence of water from the outer layer of the silage makes the proper fermentation impossible, and molding takes place. Silos built of stone or porous cement should either be washed with a cement on the inside or given a treatment of tar or some sort of waterproofing material.

It is necessary also that the walls be smooth, with no ledges or projections. Wherever there is a ledge, settling does not take place uniformly and air enters, causing the silage to spoil.

A further essential of the wall is that it be strong enough to withstand the pressure of the silage. It should also be durable enough to last for some years.

The hay-crop silages with high moisture content exert a greater lateral pressure than does corn silage or hay-crop silage of normal moisture composition. Usually, extra reinforcement is added to the lower part of the silo when hay-crop silages are to be stored.

Foundation and Floor. The foundation should be constructed of concrete. Usually there is no floor put in the silo. The ground will absorb some of the excess moisture and the silage will keep better in the bottom of the silo than when it has a tight floor. It is desirable to provide a drain in the bottom of the silo.

Roof. A roof is desirable but not absolutely necesary. It prevents snow and rain from entering the silo These, especially the snow, often make the silage unpleasant to handle. A roof also reduces the freezing to some extent.

Doors. The door of the silo should be airtight and flush on the inside. Properly fitting doors are one of the essentials of a good silo. If the doors do not fit tightly air will get in and spoiling will result.

Shape. Practically the only silos now in use are round. They are built in this form because in a square silo the corners are difficult to fill Besides, the round silo is stronger.

Removal of Silage. The silage is usually thrown from the silo by hand A cart that fits under the chute will save an extra handling of the silage. Silo unloaders are on the market that are reported to work satisfactorily. Also, as with the airtight silo, a conveyor at the bottom unloads it mechanically.

Moving Silage to Manger. The silage cart is the standard means of moving silage from the silo to the manger A few farmers have built conveyors from the silo chute to mangers or feed bunks which distribute the silage without hand labor.

Precautions in Feeding Silage. When cows are first fed silage after not receiving it for a while, some of the flavor may be carried over in the milk. This is especially true if it is fed just before or during milking Silage fed after milking will seldom produce any off flavor in the milk

Spoiled silage should not be fed. Although cows are not as sensitive to moldy and other types of spoiled feed as are some other animals, there is danger of causing digestive disturbances The feeding of silage before the fermentation process is complete will sometimes cause cows to go off feed Frozen silage should

be thawed before being fed Good silage is one of our best milk-producing feeds Use it wisely.

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14

Hay and Haymaking

High quality hay is leafy, green in color, soft and pliable, free from mustiness, and is palatable. The importance of good hay for winter feeding can hardly be overestimated. Dairy cows, with their large feed capacity, are capable of consuming large quantities of rough feed, and their digestive systems are specially adapted to the digestion of such feeds. Hay can be easily grown on most farms in the United States and hence is a very economical feed, since homegrown feeds are usually much cheaper than purchased feeds. Pasture makes an ideal feed for dairy cows during the summer, but some of the forage crops must be dried for use during the winter when pasture is not available. If well cured and preserved, they make one of the most economical feeds that are available at that time. Hay can be fed in conjunction with silage and grain or alone with grain. Occasionally, it is fed as the sole feed, but dairy cows cannot consume a sufficient quantity of hay alone for maximum milk production.

Kinds of Hays. Hays are divided into two groups, namely, legume and nonlegume. Although legume hays are generally superior to the nonlegumes in the amount of protein, in the mineral and vitamin content, and in palatability, this difference may not always exist, since a great deal depends upon the soil on which the hays are grown. A grass hay, for instance, grown upon a soil that is rich in nitrogen, lime, and phosphorus, cut early, and well cured, may be superior in many respects to a legume hay not so well grown and cured. The fact that a hay is legume is not always a sign that it is a good hay. Other factors must be considered to determine the difference between good hay and poor hay, such as time of cutting, curing, storing, and the kind of soil upon which it is grown.

LEGUME HAYS Good legume hay has many characteristics that make it of special value for dairy cattle Some of them are as follows

1 With the exception of corn silage, legume hay will produce more digestible nutrients on a given area than any other crop This is especially true of alfalfa, which will yield two or three crops during the season Other legumes yield heavily but not so much as alfalfa

2 More digestible protein can be grown on an acre with legume hay than with other common crops This is especially important because of the fact that most of the other homegrown feeds are comparatively low in protein Since the nonlegumes and cereal grains are low in protein, legumes are an excellent supplement to them Furthermore, the protein of legumes is of excellent quality Heifers will grow normally when all the protein comes from the alfalfa plant

3 Well cured legume hays are higher in the vitamins necessary in the nutrition of dairy cattle than any other of the common feeds They are particularly rich in carotene, the precursor of vitamin A, and may contain considerable vitamin D They are also a rich source of vitamins E and G Nonlegume hays, when well cured, and corn silage may also contain considerable amounts of these vitamins, but the cereal grains are low in them

4 The legume hays are especially rich in calcium In fact, the dairy cow must depend largely on the legume for her calcium supply, as the nonlegume hays, silage, and grains are all low in this element The legume hays are only moderately rich in phosphorus, the amount depending upon the amount in the soil upon which they are grown They are usually considered a fair source of this element

5 Good legume hay is palatable, adds the necessary bulk, and has a good physiological effect upon the digestive system of the cow With the possible exception of silage, no winter roughage is better liked than good legume hay

6 Legume hay is easily grown, requires no cultivation, and keeps the ground covered, thus preventing erosion better than the cultivated crops Alfalfa hay continues for several years with one seeding Sometimes, there is difficulty in getting a good stand of alfalfa as the soil must be especially prepared for such

a crop, well drained, and not too acid Soybeans and some of the other legumes will grow on soil where the acidity is higher than is required for growing alfalfa.

The principal legume hays grown in the United States are alfalfa, clover (red, mammoth red, alsike, crimson, ladino, and sweet), soybean, cowpea, peanut, and lespedeza. These crops have been discussed in a previous chapter

NONLEGUME HAYS Grass hays, such as timothy, redtop, blue grass, brome grass, Sudan grass, and sorghum, are usually not as good feeds for dairy cattle as the legumes They are, as a rule, less palatable, and contain less protein, mineral matter, and vitamins than the legume hays However, if they are harvested early and are properly cured, they may be equal to legume hay in palatability, and their protein content may be not far under that of ordinary legume hay If the soil upon which they are grown has been fertilized with a high nitrogen fertilizer, the protein content will be greatly increased

Grass hays have been popular in most of the United States, even though legume hay have many advantages over them The reason for this is the ease with which they can be grown and cured

GRAIN HAYS Considerable hay is made with the small cereals, such as oats, barley, wheat, and rye These make fair hay if cut early when the grain is in the early milk stage, and compare very favorably with the grass hays They are low in protein and in minerals, however, and are adapted more for an emergency hay crop than for a regular hay crop

MIXED HAYS Many farmers grow a legume hay and a non legume hay in combination, calling it mixed hay Some of the most common mixed hays are clover and timothy, alfalfa and timothy, soybeans and Sudan grass, oats and peas, and oats and vetch. Any other combination in which a legume and a non legume is grown would be called a mixed hay The composition of such hay will depend upon the proportion of each kind of hay which it contains It is usually cut early, and hence the non legumes are higher in protein than when cut at the ordinary time The practice of growing mixed hay is to be recommended where difficulty is experienced in getting a stand of legume hay It can be made into high-quality hay

Grades of Hay Good, well cured hay makes an excellent feed for dairy cattle, but much of the hay produced in the United States cannot be classified as good hay As a consequence it does not make as good feed as if it were well cured This poor hay is due in part to cutting when the hay is too ripe, in part to unfavorable weather conditions at the time of cutting, and to improper curing, harvesting, and storage Furthermore, the real difference between good hay and poor hay was not fully understood in the past The Department of Agriculture[*] has set up grades on hays which have done much to educate the producers of hay to the desirable factors

Hays for which there are standards are divided into eleven groups as follows Group I alfalfa and alfalfa mixed hay Group II timothy and clover hay Group III prairie hay Group IV Johnson and Johnson mixed hay Group V grain, wild oat, vetch, and grain mixed hay Group VI lespedeza and lespedeza mixed hay Group VII soybean and soybean mixed hay Group VIII cowpea and cowpea mixed hay Group IX peanut and peanut mixed hay Group X grass hay Group XI mixed hay

The grades of alfalfa and alfalfa mixed hay depend upon the leafiness, percentage of green color and maximum percentage of foreign matter The grades of timothy and clover depend on green color and maximum percentage of foreign material Grades for the other groups have been worked out in a similar manner The standard grade requirements for alfalfa and alfalfa mixed hay and for timothy and clover hay are stated in Table XXX Because of this grading, much of the hay is now being purchased upon grade and as a result the quality of hay has been improved

Effects of Curing on Quality of Hay Hay should be cured in such a way as to preserve the leaves and the green color and drive out sufficient moisture so that it will keep well in storage

Importance of Leaves The leaves on some of the hay crops, such as alfalfa soybeans, and other legumes, are very important In the alfalfa plant the leaves make up about 47 per cent of the crop but their protein content is 141 per cent higher than that in

[*] U S D A *Handbook of Official Hay and Straw Standards* (1949)

TABLE XXX

GRADE REQUIREMENTS FOR ALFALFA, ALFALFA MIXED, AND TIMOTHY AND CLOVER HAY

U S Grade Number	Leafiness of Alfalfa and Alfalfa-Mixed, per cent leaves	Percentage of Green Color		Maximum Percentage of Foreign Material	
		Alfalfa and Alfalfa Mixed	Timothy and Clover	Alfalfa and Alfalfa Mixed	Timothy and Clover
1	40 or more	60 or more	40 or more	5	10
2	25 or more	35 or more	30 or more	10	15
3	10 or more	10 or more	10 or more	15	20

the stems Twenty eight pounds of alfalfa leaves contain as much protein as 100 pounds of stems The leaves of alfalfa are also much higher in calcium and in vitamins than the stems, and they are much more palatable Grizzard * found that the leaves of alfalfa were almost 3 times as high in calcium and 1½ times as high in phosphorus as the stems Snell † has given the chemical analyses of the stems and leaves of soybean hay as shown in Table XXXI From this table it can be seen that more than half of soybean plant is in the leaves and that it contains very much

TABLE XXXI

CHEMICAL COMPOSITION OF TWO SAMPLES OF SOYBEAN HAY

	Leaves		Stems	
	Sample 1, per cent	Sample 2, per cent	Sample 1, per cent	Sample 2, per cent
Part of plant	55 39	64 02	44 61	35 98
Crude protein	19 37	21 07	5 18	7 33
Ether extract	3 48	2 38	0 87	0 76
N free extract	35 34	35 37	28 22	26 51
Crude fiber	22 11	21 38	49 64	49 18
Ash	9 47	9 80	5 46	5 88
Water	10 00	10 00	10 00	10 00

* *J Am Soc Agron*, 27 81

† *La Agr Exp Sta Bul* 257

more than half of the food value, being higher in protein, ether extract, nitrogen free extract, and minerals The stems are much higher in crude fiber.

Unless care is taken in curing these crops much shattering will result, and many of the leaves will be broken off In this way a considerable part of the protein, ether extract, nitrogen-free extract, and ash will be lost, and the resulting hay will be considerably lessened in food value

IMPORTANCE OF GREENNESS The green color of the leaves indicates the amount of carotene, the precursor of vitamin A, that is present The importance of this element, not only for the nutrition of the animal but also for its value in the milk produced by dairy cows, has already been mentioned Carotene is easily oxidized, probably as the result of an enzymatic process not caused by the sunlight but affected by it in an indirect way by producing temperatures which accelerate enzymatic action The Department of Agriculture has calculated the carotene content of various feeds, including the different grades of alfalfa hay and timothy hay, as shown in Table XXXII It can be seen by

TABLE XXXII

THE CAROTENE CONTENT OF ALFALFA AND TIMOTHY HAY *

Feed	Determination Number	Water, per cent	Carotene per Gram of Dry Matter: High Gamma	Low Gamma	Average Gamma
Fresh green alfalfa	5	79 6	412 0	267 0	326 0
U S No 1 alfalfa hay	6	8 6	117 1	33 6	60 6
U S No 2 alfalfa hay	2	8 6	16 3	13 7	15 0
U S No 3 alfalfa hay	2	8 6	12 4	1 0	6 7
U S No 1 timothy hay	3	11 6	24 5	9 0	18 9
U S No 2 timothy hay	1	11 6	8 0	8 0	8 0
U S No 3 timothy hay	2	11 6	10 7	1 6	6 1

* *U S D A Yearbook of Agriculture* (1935)

this table that there is considerable loss of carotene in the curing of hay, even under good conditions, but, with the exception of pasture and green feeds, well cured hays are the best source of this compound It must be realized, however, that both hay and

pasture are subject to great variations in their carotene content.

VITAMIN D CONTENT OF HAY Hay when it is first cut contains very little if any vitamin D, the antirachitic vitamin. The ergosterol in such hay, however, when cured in the sun, changes into vitamin D Sun-cured hay, with the exception of direct irradiation of the animal herself with the ultraviolet light of the sun's rays, is about the only natural source of this vitamin available to the cow The antirachitic potency of dried roughage depends upon the intensity of the sunlight, the length of exposure, and the amount of ergosterol in the plant.

It has been shown * that hay cured away from the sunlight contains no appreciable amount of vitamin D, but hay exposed to the sunlight for some time may develop considerable antirachitic potency Even sun-cured timothy has been found to contain considerable vitamin D Two pounds per day of such hay will prevent rickets in growing calves until they are about 1 year of age The legume hays are usually considered better sources of this vitamin than the nonlegume hays

In a study † at the Bureau of Dairy Industry farm, barn-cured alfalfa hay that had not been exposed to the sun was fed to calves until they were 8 months of age The calves were kept in a darkened barn, however, the hay contained sufficient vitamin D to protect the calves from rickets It is believed that any vitamin D in fresh-cut hay comes from the dead leaves and stems and the leaves that have yellowed.

Since the vitamin D potency of hay depends upon its exposure to sunlight, and since the sunlight seems to accelerate the destruction of the carotene in hay, it can be seen that it is a difficult process to cure and handle hay in such a way as to obtain the maximum amount of both these factors Long exposure to sun has other deleterious results, such as loss of leaves Thus, the quality and carotene content of the hay is usually given first consideration in the curing of hay

Effect of Soil on Quality of Hay That the soil has an effect upon the hay grown on it has been fully demonstrated.‡ In fact, some soils are so deficient in certain minerals such as cal

* *J Agr Research* 46 235

† *Rep Chief B D I U S D.A.* (1949)

‡ *J Am Soc Agron* 27 81

cium and phosphorus, that the herbage grown upon it will not support normal well-being in dairy cattle Alfalfa grown on soils low in phosphorus will be low in that element Grass hays will be affected also by the amount of calcium and phosphorus in the soil The amount of protein in hays can be materially increased by adding a nitrogen-containing fertilizer to the soil High-quality hay can be produced, then, only upon soils that are rich in available minerals

Time of Cutting. One of the common mistakes in making hay is to let the hay become too ripe before cutting Hay cut early is higher in protein, is lower in crude fiber, contains more of the vitamins, is more palatable, and will shatter less than that allowed to become ripe

It is usually recommended that alfalfa hay should be cut when it is one-tenth in bloom, after which time the protein decreases and the crude fiber increases It is wise not to cut when too young lest the stand be weakened Clover hay should be cut when it is one-fourth in bloom The total yield may increase after this, but the protein content decreases, as do the digestibility and palatability

Soybeans are best fitted for hay when the pods begin to fill If the crop is cut earlier the percentage of protein is higher, but the total yield is not so large and the difficulty of curing is much greater If cutting is delayed beyond this, the stems become hard and woody, and many of the leaves are lost

Timothy is too often left until it is quite ripe, when it has lost much of its food value Experiments have shown that the protein of timothy decreases rapidly after it starts to bloom, as do its palatability, its digestibility, and its vitamin content Timothy should be cut before it comes in bloom, and should never be allowed to ripen

All grass hays make much better feed for dairy cattle if they are cut when they first begin to come into bloom The small grains, when cut for hay, should be cut when the grain is in the early milk stage and before they begin to harden

The importance of early cutting cannot be overemphasized The percentage of protein, the digestibility, the amount of minerals and vitamins, and the palatability decrease as the crop increases in maturity

Curing the Hay In curing hay it is necessary to keep it from becoming bleached by the sun and rain, to preserve the leaves from shattering, and at the same time to drive out sufficient moisture so that it will keep in the barn without heating and spoiling

There is perhaps no best time to cut hay, although it should not be cut until the dew is gone It should then be allowed to lie in the swath until it is thoroughly wilted When mowing, one may use the hay crusher, which crushes the stems of the cut plants These crushed stems will dry much more quickly than will the uncrushed, and the stems are said to be softer and the resulting hay more palatable After wilting and before the leaves become dry and brittle, it should be raked in windrows, preferably with a side delivery rake Care should be taken not to rake the hay when it is so dry that the leaves will shatter Usually, small windrows are to be preferred to large ones The length of time hay should remain in the windrow depends upon the weather conditions and the crop and the method of harvesting and storing Soybean hay is harder to cure than alfalfa, clover, or the grass hays since their stems are larger and harder to dry out Small lots of hays are sometimes put up in cocks to protect them against rain, but this requires much more labor and has become obsolete on most farms The grass hays are easier to cure than the legumes as the leaves are not so easily broken off Care must be taken with all hays, however, in order to preserve them properly

When hay is ready to be put into the barn or stack it should not contain more than 25 per cent moisture, and preferably not more than 22 per cent if it is to be stored in large amounts If there is more moisture than this, the hay will heat and fermentation will take place, causing loss of nutrients. In case of threatening rain, one or two loads of hay may be put into the barn before it reaches the desired dryness, if care is taken to keep it well spread out so that it is not more than 2 or 3 feet deep at any place and not covered over with other hay before it has had time to dry

Harvesting the Hay Crop It is important that the hay be stored as quickly as possible, to prevent too much exposure to the

sun and the hazard of rains In many sections of the country it is difficult to store the hay before it has been rained on Several methods are being used to reduce the time required for the curing and harvesting of the crop Most of them save considerable time and labor over that of pitching the hay by hand on the wagon or truck for hauling to the barn or stack Any one of the following methods are now being used

1 Hay Loaders The hay loader is attached to the wagon or truck and will load the hay from the windrow with little effort The hay should be dry when it is to be stored in the mow or stack, but the hay loader may also be used to load wet hay for the silo or partially dried hay which is to go on the mow hay drier

2 Buck Rakes The use of a buck rake is a rapid method of getting hay from the windrow to the stack It is especially valuable when the hay is to be stacked The hay should be dry or nearly so when the buck rake is used although it can also be used with freshly cut or partially dried hay

3 Pickup Balers The use of the pickup baler which bales the hay from the windrow has gained great popularity in many sections of the country There are many types of balers, some putting out square, others rectangular, and still others round bales Some are sliced, others are rolled The hay should be quite dry if this method is used unless the bales are to be put on a hay drier Often, a baler is equipped with an elevator for loading the bales on a truck or trailer which follows the baler

4 Field Choppers Many dairymen are gathering the hay from the windrow with a field chopper This machine chops the hay into suitable lengths and blows it into a truck which runs alongside The dryness of the hay depends upon how it is to be cured If in a regular mow without additional drying, it should be a little drier than loose hay If it is to be put on a mow hay drier it can contain considerable moisture and of course, if it is to go into the silo it needs only to be wilted

Putting up Hay on Custom Basis There is an increasing use of hay and silage making machinery on the custom basis A person may own the equipment and have as his main business the custom work for other farmers The actual cost may not vary a

great deal, whether the farmer owns his equipment or custom hires it However, he does not have the investment tied up in the equipment One disadvantage to the custom method is that it may be difficult to get the job done just when it should be done Suggested rates for charging for custom work are given in Table *H*, in the appendix

Drying Hay in the Barn Since it is often difficult to dry the hay completely in the field, several methods have been worked out to cure hay by other means

DEHYDRATING Because of uncertainty of weather conditions, mechanical curing of hay has been tried in many places By this method the hay is hauled directly from the field just after being cut. It is then usually chopped as it enters the drier, where it passes over hot drums which drive off the moisture until it contains from 10 to 15 per cent The hay is then either sacked or blown into the storage mow The advantages of this method are that weather conditions interfere little with the operation, it eliminates the loss due to shattering of leaves, there is less chance of its heating and spoiling in the mow, its carotene con tent is preserved, and it is generally a little more palatable than ordinary cured hay Hay cured in this way has very little vitamin D, as it is not exposed to the sun's rays The cost of such machines has made them prohibitive except on large farms where they can be used enough to pay for their cost and operation

DRYING HAY BY FORCED VENTILATION The problem of curing hay varies in different sections of the country Weather condi tions that affect hay curing vary widely Some areas are char acterized by cool nights accompanied by high humidity and heavy dews especially during a part of the haymaking periods For this reason, curing is delayed and the hay has to remain in the field for a longer time after cutting Often, there is much rainy weather during haymaking time It is difficult to produce good quality hay under these conditions

THE BARN HAY DRIER. The barn hay drier is often used to complete the curing of partially cured hay A system of air ducts or a main duct and a slatted floor is used to distribute atmospheric air through the hay (Figure 20)

Curing Loose Hay. The drier is located in the hay mow and a fan is used to drive air through the duct system and the hay. With this method of curing, the hay may be placed on the drier with a moisture content of as much as 40 to 45 per cent. The barn drier then completes the curing of the hay. The handling of hay with this moisture content results not only in reten-

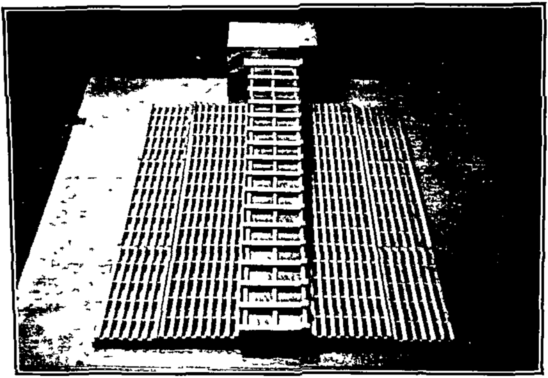

FIG. 20. A model of a barn hay drier, showing air-distribution system (V.P.I.).

tion of more leaves but also more of its green color and carotene content than when it is entirely field-cured. This is true under favorable haying conditions, but a still greater difference would occur with unfavorable weather conditions.

The use of the hay drier requires the handling of a large tonnage of forage because of its high moisture content. For maximum efficiency in the drying process, great care must be taken to distribute the hay evenly over the entire duct system.

Drying Chopped Hay. The earlier driers were designed principally for loose hay. Modifications have been made in the air-distribution system for drying chopped hay. High-quality hay has been made with this method. However, a slightly less

moisture content is essential and the chopped hay must be distributed evenly over the drier. The hay should be cut in as long pieces as can be blown onto the drier. Short cuts of dried hay may cause sore mouths in cows.

Drying Baled Hay. Some changes in the distribution of the airflow make the hay drier capable of curing baled hay. For curing in bales the hay must be somewhat drier than when stored as long loose hay. It should be baled rather loose, and placed on the drier so that as much air as possible is forced through the bales.

Value of Barn Hay Drier. The barn drier permits the dairymen to put his hay in the barn with a minimum of exposure to the weather. It makes possible the saving of hay under weather conditions which would otherwise practically ruin it. More of the protein, leaves, green color, and carotene content of the hay can be preserved. In experiments at the Virginia Experiment Station * the crude protein content of third cutting alfalfa hay was 17.6 per cent for the field-cured hay and 20.2 per cent for the barn-cured hay. The coefficient of digestibility of the crude protein was 70.8 per cent for the field-cured hay and 74.3 per cent for the barn-cured hay. The differences in the milk-producing abilities of the two hays were not great, although the group of cows fed the barn-cured hay produced slightly more.

The loss of dry matter in hay from the time of cutting until fed was reported by the Cornell Experiment Station † to be 15 per cent for barn-cured hay and 24 per cent for field-cured hay.

Electricity Required. The amount of electricity required to operate the fan depends upon the moisture in the hay when placed on the drier and upon the weather conditions. Under average conditions of both, it will require about 50 kilowatt hours per ton of dried hay.

Drying with Supplemental Heat. If heated air is forced through the hay it will dry faster. Also, hay with a higher moisture content can be placed on the drier. An oil burner is the usual source of supplemental heat. This is used in conjunction with the fan-and-duct system in the usual barn drier.

* *Va. Agr. Exp. Sta. Bul.* 431 (1950).
† *Cornell Exp. Sta. Bul.* 874 (1951).

The supplement heater may be either of two types, a stationary unit with a fixed location or a portable unit used with various drier units With the stationary units, the drier is usually in a permanent shed or special building The hay is dried in a period of 50 to 60 hours and removed for storage elsewhere and the drier can be reloaded at once

The use of supplemental heat not only does the job in a very short time but makes possible curing, regardless of weather and air conditions

PRESERVATIVES FOR CURING HIGH MOISTURE HAY Some preparations have appeared on the market with the claim that they will prevent spoilage of grain and hay stored with a high moisture content The Kansas Experiment Station * tested some of these preparations as well as other chemicals known to be mold inhibiting agents They reported that the commercial preparations contained essentially sodium carbonate, sodium bicarbonate, calcium carbonate, and magnesium carbonate The manufacturers' claim of effectiveness was based on the release of carbon dioxide to displace air in the grain or hay and in that way prevent heating and molding The Kansas Station reported that the results of their work indicated that these preparations would not prevent molding and spoilage in grain and hay stored with high moisture content Salt is occasionally added to high moisture hay It has not been found to prevent molding or heating

Hay Silages In order to preserve hay without interference from the weather, the silo has frequently been used As already pointed out silage made from such forages lacks sufficient sugar to preserve it satisfactorily without special care Special methods have been devised, however, by which it is preserved successfully, for example, A I V silage and molasses silage These have been discussed in a previous chapter

Storage of Field Cured Hay Field cured hay is usually stored loose in mows or in stacks When stored in the barn it is important that the hay be well distributed When put in with a hayfork too much should not be allowed to drop in one pile, otherwise it may heat and spoil Some farmers chop the hay with a forage harvester or with a hay cutter and blow it into the

* *Kansas Agr Exp Sta , Prog Rept* No 6 (1951)

mow Such a method has the advantage that considerably more hay can be stored in a given space and it is easier to remove, since it is not bound together like loose hay Care must be taken, however, that the hay is well dried, or it is likely to heat There is some danger of spontaneous combustion with hay stored in this way unless it is more thoroughly dried than when stored loose

In storing hay in the bale, the hay needs to be a little drier than for storing loose Unless quite dry the bales should be set on edge with room for air circulation between them and stacked so as to give a maximum surface area exposed for drying

Air dry hay at time of feeding usually contains from 10 to 12 per cent moisture If hay is stored with 25 per cent moisture, which is a safe storage content, nearly 300 pounds of water must evaporate from each ton of hay stored

BROWN HAY Sometimes, because of very unfavorable weather conditions, good hay cannot be obtained by the ordinary methods of curing, and it is then made into what is known as "brown hay" The hay is allowed to dry until about 50 per cent of the moisture has been removed, and then it is packed in a stack or in piles Fermentation takes place and the hay becomes very hot, but the temperature should not exceed 175°F The heat dries out the hay During fermentation much of the dry matter is oxidized so that it may lose as much as 40 per cent of the total dry matter Digestibility is also decreased The hay, however, is often quite palatable, but because of the great waste in dry matter the method is not recommended The vitamins are probably destroyed in the process of fermentation

DANGER FROM SPONTANEOUS COMBUSTION If hay is put in the mow or stacked when it contains too much moisture, it may ferment very rapidly, releasing a large amount of heat If it is allowed to continue for a month or 6 weeks, the temperature may rise to 300°F to 400°F when spontaneous combustion may occur and the hay burst into flame This may be prevented by taking care not to store hay with an excessive amount of moisture, or, if this is unavoidable, to distribute the hay well, not allowing it to become packed Leaks in the roof, unknown to the owner, sometimes cause this trouble No trouble has been ex

perienced with spontaneous combustion with the use of the barn hay driers

Feeding Hay Since hay is one of the cheapest winter feeds produced on the farm, and since dairy cows are well adapted to its consumption and digestion, it should be fed in large amounts The amount that a dairy cow will eat, however, depends upon the quality of the hay and the amount of other feed

Because of its bulky nature, hay alone cannot be consumed by cows in sufficient quantity to produce maximum amounts of milk, it is usually fed with some other more concentrated feed Cows have produced fairly large amounts of milk and butterfat when fed on legume hay alone, but not as much as they would have produced if they had been fed some grain Some dairymen maintain that it is more profitable to feed the cows large amounts of roughage and small amounts of grains, even though the maximum amount of milk is not obtained, because of the lower cost of the roughage as compared to the grain The right proportions depend upon several factors When the price of milk is very low and the price of grain is high, there seems no question but that it might be more economical to feed a ration consisting largely or entirely of roughage But if the price of milk is high and the cost of grain is low, it usually is more profitable to feed a full grain ration Ordinarily, a moderate grain ration with fairly heavy roughage feeding is to be recommended

Legume roughages and corn silage go well together in making a dairy ration The hay adds protein and the silage adds succulence Both are palatable and produce high yields per acre Legume hay, however, can be fed satisfactorily as the sole roughage, and when water is available at all times it will produce just as much milk as when fed in conjunction with corn silage Under this condition it is necessary to feed more hay One pound of hay is equivalent to about 3 pounds of silage in digestible nutrients, but the legume hay contains considerably more protein

The general rule for feeding hay is to feed all that the cows will clean up As stated before, the amount that they consume depends upon the quality of the hay and the amount and kind of other feeds When fed with corn silage and a full grain ration,

they will consume about 1½ pounds of hay and 3 pounds of silage for each 100 pounds of live weight.

When fed without silage but with a full grain ration, they will consume about 2½ pounds of hay to each 100 pounds of live weight. As noted before, about 1 pound of hay is substituted for 3 pounds of silage.

When fed without silage but on a limited grain ration, cows will consume as much as 3 to 3.5 pounds of hay to each 100 pounds of live weight.

These consumption figures are simply guides that one might use in figuring the amount of hay necessary under different feeding methods.

Methods of Feeding Hay. The methods of feeding hay is receiving much consideration from the labor-saving viewpoint. The feeding of baled hay has eliminated much of the harder work. With loose hay, the hayfork used to put the hay in the barn may be reversed to do some of the heaviest work in removing the hay.

Some feed barns are arranged with the hay stored on the same level that the cows are housed, with movable hay mangers arranged between the cows and the hay. This plan reduces the handling of hay to a minimum.

A cylindrical upright storage with a self-feeder system around the circumference at the bottom has been developed for feeding chopped hay. It resembles a silo and is made of perforated metal. A cone is built in the bottom of the storage to cause the hay to slide to the outside where the cows can reach it. As they eat, the weight of the hay above causes more to slide down. This storage can be constructed with an air duct in the center, extending from the ground level to the top. The duct can be equipped with a hay drier.

More emphasis must be placed on the greater utilization of pasture, hay, and silage. These must be produced and made available to the cow in the condition under which they retain their greatest nutritive value and with a minimum of hand labor.

Supplementing Hay. Does it pay to feed grain to dairy cattle? This question has been considered by many dairymen. Most of the experiments that have been carried out to solve this problem

have been in the area where alfalfa hay is easily grown and where the quality of alfalfa hay is of the best. The answer depends upon several factors which are stated by the Nevada Experiment Station * as follows.

Favoring Grain Feeding	*Opposed to Grain Feeding*
High hay prices	Low hay prices
Low grain prices	High grain prices
High prices for dairy products	Low prices for dairy products
High producing cows	Low producing cows
Poor quality hay	Good-quality hay

"The correct answer to the question 'Does it pay to feed grain to dairy cows?' varies with changes in economic conditions and in the productive capacity of the cows and must always be qualified so as to apply to some given combination of the factors mentioned above." As a rule, however, it would seem advisable to feed at least a limited amount of grain for the most economical results.

Data from eight experiment stations that were cooperating in a feeding project were summarized by the United States Department of Agriculture † (Table XXXIII). Data is given on roughage consumed by cows on various levels of grain feeding and on the ratio of milk produced to grain fed. As more grain was fed the cows ate less roughage but had a greater total nutrient intake. For each pound of grain consumed the cow reduced the hay intake by approximately 0.7 pound. Thus, about 0.35 pound of total digestible nutrients in the hay was replaced with approximately 0.7 pound from grain.

On the basis of current price figures for milk, grain, and hay, computations can be made from this table to arrive at the most profitable level of grain feeding. The relation of the cost of hay to grain, as well as the price of milk, will influence the level of grain feeding that is most profitable. As the price of milk declines, it will generally be more profitable to produce the milk with more roughage and less grain.

* *Nev. Agr. Exp. Sta. Bul.* 140.
† *U.S.D.A. Tech. Bul.* 815 (1942).

TABLE XXXIII

Data on Various Levels of Grain Feeding and Its Relation to Roughage Intake and Milk Produced

Level of Feeding from Lowest to Highest	Live Weight, pounds	Roughage Expressed as Hay Equivalent per 100 Pounds Live Weight, pounds	Total Hay Equivalent Fed in a Year pounds	Grain Fed in a Year pounds	Grain Fed during Lactation Period pounds	*Adjusted* Total Digestible Nutrients pounds	Estimated Quantities of Milk These Feeds Would Produce pounds	Milk Produced per Pound of Grain Fed during Lactation, pounds
1	1080	2 9	11 338	0	0	5102	6438	
2	1090	2 8	11 048	450	420	5376	7020	16 7
3	1100	2 7	10 751	900	840	5642	7517	8 9
4	1110	2 6	10 447	1350	1260	5901	7947	6 3
5	1120	2 5	10 136	1800	1680	6154	8317	5
6	1130	2 4	9 817	2250	2100	6400	8639	4 1
7	1140	2 3	9 492	2700	2520	6638	8915	3 5
8	1150	2 2	9 159	3150	2940	6868	9156	3 1
9	1160	2 1	8 818	3600	3360	7091	9366	2 8
10	11[illegible]0	2 0	8 471	4050	3780	7307	9550	2 5
11	1180	1 9	8 116	4500	4200	7514	9 08	2 3
12	1190	1 8	7 754	4950	4620	7713	9847	2 1
13	1200	1 7	7 385	5400	5040	7905	9971	2

STORAGE SPACE REQUIREMENTS

The space required to store hay depends on its looseness, the depth of storage, its moisture content when put in storage, and the kind of hay. Table *E* in the appendix gives the weight per cubic foot and the cubic feet required to store a ton of hay and various other materials *

Hay that is chopped packs closer than loose hay The shorter the cut the less space required Hay baled in the field with a pickup baler is usually baled loose and will use less than half as much space as loose stored hay Hay that is baled when it is completely dry and pressed very tight will require only about one fifth as much storage space as long hay in loose storage

* *Hoards' Dairyman* (Mar 25, 1951)

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15

Pastures

Pasture is the natural feed for dairy cattle and in many respects the best. Abundance of good pasture provides most of the requirements of a good dairy ration for economical milk production Of the total land area of the United States 1905 million acres about 707 million acres or more than one third are used for grazing This does not include woodland and forest grazing areas There are approximately 110 million acres of pasture land that are suitable for cultivation the remainder being nonarable in the present condition The total land used for crops is 270

Fig 21 Ladino clover and orchard grass pasture (V P I)

million acres Thus, approximately 40 per cent of the arable land is in pasture

Thirty-five per cent* of the total feed for livestock is in the form of pasture Except in specialized dairies in a few small sections of the United States, pasture is of the greatest importance in the production of milk It has been estimated that more than half of all the milk produced in this country is produced from pasture In many sections, the number of cows kept is determined by the number that can be pastured There is an old Flemish proverb that says, "No grass, no cattle, no cattle, no manure, no manure, no crops" This is true to a certain extent in many sections of our country today Fresh pasture is palatable, is succulent, and has a good physiological effect upon the cow It is rich in protein, vitamins, and minerals However, one should realize that pasture is not a concentrate and that heavy milking cows cannot consume enough pasture for maximum milk production The pasture should be supplemented with grain if the maximum production is to be obtained

DESIRABLE CHARACTERISTICS OF A PASTURE

A pasture, to be of the greatest benefit to the dairyman, must possess the following desirable characteristics

1 Young and Growing The best pasture is a young pasture and in order for it to remain good it must be kept actively growing Young, actively growing pastures are high in protein, often reaching 15 per cent or more on the dry-matter basis They are soft and tender, containing less crude fiber and lignin than old pastures, and hence are more digestible They are rich in all of the vitamins or their precursors They are rich in phosphorus and in calcium The vitamins and minerals decrease as the plant grows older

2 Dense and Abundant A pasture to be good should have a dense sod, as this determines the amount of feed that is available for the cattle The job of harvesting the pasture crop by the cow is a big task An average dairy cow will consume about 150 pounds of pasture daily Such a pile of grass would measure

* *Grass, U S D A Yearbook of Agriculture* (1948)

6 feet in diameter and 3 feet high at the center To gather such a quantity of feed is quite a task, even when the pasture is in optimum condition

3 THE PROPER HEIGHT Cows seem to be able to harvest the pasture best when it is about 6 inches tall rather than when it is shorter or taller When it is shorter, they cannot get as much at one bite When it is taller, the grazing is done by biting into the sward to the depth of 4 or 5 inches As the blades and stems are more widely separated, the amount of grass gathered per bite is considerably less Another method is for the cow to pull the herbage sideways with the aid of the tongue When this is done the amount taken with each bite is increased but the number of bites taken per minute is reduced because of the increased time required to manipulate and swallow the taller herbage

4 PALATABLE AND DIGESTIBLE. The palatability and digestibility of the forage will determine the amount of feed that the cows will consume and how much they will be able to convert into milk. Plants change in their composition somewhat differently For example, orchard grass, Reed s canary grass, and some of the other grasses become woody and lose their palatability much sooner than some others Most legumes with the exception of the perennial lespedeza brome grass, and Sudan grass will retain their palatability and nutritive value for a relatively long period of time Most of the grasses, however, change in their digestibility and palatability as the season advances It is important that there be a mixture of grasses or legumes in the pasture that will remain palatable and nutritive throughout the entire season

5 EVEN DISTRIBUTION THROUGHOUT THE SEASON To have a good pasture it is necessary that there be some actively growing pasture plant from early spring to late fall Different grasses show different characteristics in regard to their growth during the season Bluegrass pasture for example, grows well in the spring and fall but fails to grow during the hot part of summer It is necessary then to have some pasture plant that will do well in hot weather to supplement the bluegrass at that period Unless there is abundant pasture at all seasons cows cannot keep their milk production uniform. A study * at the Kansas Station

* *J Dairy Sci.*, 25 779 (1942)

showed that cows on good pasture spend about 50 per cent of the time grazing, on fair pasture they spend 55 per cent of their time grazing, and on poor pasture 62 per cent

6 CONVENIENT TO THE STABLE Dairy cows should be provided pasture which is not too distant from the stable, as they should not be required to walk great distances to and from the pasture When improving a pasture, a dairyman should start with that nearest the barn Considerable energy is required for a cow to walk far to and from pasture

7 WELL WATERED The importance of water in the pasture during the hot, dry months cannot be overemphasized Cows require a large amount of water at all times, and in hot weather this requirement is increased greatly If there is no stream in the pasture, fresh water should be provided by other means

8 FENCED PROPERLY A good pasture should have a good fence surrounding it, but good pasture management requires a flexible fencing system Rotational grazing calls for an inexpensive and temporary fence that can be moved as occasion warrants The electric fence with an automatic control and a one or two wire line is quite satisfactory Such a fence can be changed as often as needed with a minimum of work

GRASSLAND FARMING

The soil conservation programs and pasture improvement programs have caused a reduction in row crops and an increase in pasture and hay crops In some areas, especially on some individual farms there is a trend toward a complete grassland farming system The program is based on high yielding pastures along with the best legumes and grasses for abundant hay and hay crop silage for winter feed It is proving popular and profitable in certain areas

KINDS OF PASTURE

Pastures may be classified by various methods They may be classified according to the nature of the plant as perennials or as annuals, or as to the time of year that the plant makes the most growth

The more usual designation is on the basis of use: permanent, special, temporary, and winter pasture.

Permanent Pastures

Economy of Permanent Pastures. *Permanent pasture is one of the most economical feeds available for dairy cattle.* This is due to the fact that it requires very little labor and care, as compared to most other crops. Permanent pastures will last for many years if given proper care, and there is no labor expense in fitting the soil each year or in harvesting, since the cows harvest the crop themselves. Furthermore, though pastures must be fertilized at intervals, they do not require so much fertilizer as land in cultivated crops. *Pastures also tend to prevent erosion, since the ground is covered the entire year.*

Milk and butterfat can be produced by cows on pasture at a much lower feed cost than by barn fed cows. This is indicated in Table XXXIV in the 3 year average of the monthly production of the cows in the Dairy Herd Improvement Association in West Virginia, which is fairly typical of conditions in the bluegrass section of the United States.

TABLE XXXIV

MONTHLY PRODUCTION, FEED COST PER 100 POUNDS MILK, PER POUND FAT

(Three-Year Average, West Virginia Herd Improvement Association)

Month	Number of Cows	Average Milk Production pounds	Fat Production pounds	Feed Cost per Cwt Milk	Feed Cost per Pound Butterfat
January	2115	599	25.3	$1.35	$0.32
February	1961	570	24.5	1.26	0.29
March	1703	694	29.6	1.23	0.29
April	1819	652	27.9	1.10	0.26
May	2227	737	31.2	0.59	0.14
June	1937	676	28.6	0.67	0.14
July	2041	658	28.2	0.63	0.14
August	2128	655	28.2	0.68	0.15
September	2586	582	25.4	0.72	0.16
October	2164	566	26.2	0.88	0.19
November	2350	516	23.2	1.28	0.28
December	2256	560	25.0	1.36	0.31

Some of the dairymen started to pasture in the latter part of April and some continued into the latter part of October, although other feeds were fed as needed during the entire summer It can be seen that the feed cost of 100 pounds of milk and 1 pound of butterfat decreased 50 per cent during the early pasture season and increased during the latter part of the summer when the pasture became short

Yields of Pastures

There is a prevailing opinion that lands put to permanent pasture will not yield a return in comparison with the value of the land or with the returns secured from other crops Even though this is undoubtedly true of much of the pastureland in the United States as it is now handled, it need not be so The farmers in Holland make extensive use of pasture on land which is valued at $500 to $1000 per acre and which annually rents for more than most of the land in this country would bring if sold This land, however, is not considered as waste land, nor is the pasture a neglected crop Indeed, the pasture sod, some of which is more than 100 years old, is more carefully handled than any other crop on the farm Care is taken that the cattle are not placed on it too early, that it is not overpastured so that the plants are destroyed, and that the sod is as carefully and as systematically manured and fertilized as for any other crop

In the United States, a permanent pasture that will furnish abundant feed for a 1000 pound cow for the season, on 2½ acres, is considered a good one A comparison of the feeding value of a Kentucky bluegrass pasture and of a dry ration off pasture was made at the Pennsylvania Experiment Station [*] The feeding value and carrying capacity were estimated in terms of dairy cattle producing different quantities of milk Eighty pounds of green grass per head each day was taken as the basis of computation Cows producing 20 pounds of milk daily do not usually require any supplementary feed, cows producing more than this should be given some feed in addition The dry ration fed while the cows were not pastured was figured according to the Morrison standard

[*] *Pa Exp Sta Bul* 195

TABLE XXXV

VALUE OF KENTUCKY BLUEGRASS PASTURE FURNISHING 80 POUNDS OF GREEN GRASS PER DAY FOR A PERIOD OF 150 DAYS

(Cost of Feed for 150 Days)

	Pasture	Dry Ration off Pasture	Difference in Favor of Pasture
1200 pound cow			
20 pounds 3 5 per cent milk daily		$44 07	$44 07
35 pounds 3 5 per cent milk daily	$19 20	56 74	37 54
50 pounds 3 5 per cent milk daily	33 84	71 12	37 28
Average	$17 68	$57 51	$39 83

Table XXXV shows the difference in favor of pasture as compared with dry feeding This does not represent the acre value of pasture but simply the value of an area capable of producing 12 000 pounds of green grass during a period of 150 days The investigators found that it required from less than 1 acre to more than 2 5 acres to support a cow for this length of time depending upon the type of the soil and its treatment Many of the ranges and unimproved pastures require as many as 10 to 20 acres for each animal Most pastures of this kind might be easily improved

Bluegrass pasture has a wide range of carrying capacity depending on the soil the amount of fertilizer applied its management and the amount of rainfall At the Virginia Station* the number of cow days of grazing per acre per year ranged from 63 to 218 This represented 3 acres per cow for the poorer pasture and less than one acre per cow for the better pasture The length of the grazing season was about 180 days The total digestible nutrients produced per acre varied from 1020 pounds to 3266 per year Milk production had a range of 974 pounds to 3504 pounds per acre for the grazing season In most areas permanent pastures will furnish grass cheaper than any other type of pasture however they do have certain limitations

* *Va Agr Exp Sta Bul* 309 (1937)

Limitations of Permanent Pasture

The main disadvantage of a permanent pasture is that during the latter part of the season it often does not produce as much feed as is needed As the grasses become mature, they are less digestible and less palatable, and the protein, vitamin, and mineral content decrease During this period it is usually necessary to have some supplementary feed such as temporary pasture, soiling crop, or summer silage The so called dormant period of bluegrass may be due not so much to the nature of the plant as to the lack of moisture Experiments carried on by the Department of Agriculture [*] at twelve different stations in this country indicate that there is no practical way of producing a uniform growth of grasses throughout the entire growing season The total yield of dry matter varies greatly not only with the different pastures and localities but also from year to year on the same pasture

The curves in Fig 22 show the variations in the production of feed nutrients by pastures during different months Also, it will be seen that the peak months of production are different at the three locations In order to have sufficient grass during most of the grazing season, there will be surplus grass at some periods This can be used to advantage as hay or as hay crop silage

Permanent Pasture Crops

Permanent pastures consist of perennial plants and can be used under favorable conditions for many years in succession They have the advantage that they do not have to be plowed every few years, and furthermore they are adapted to conditions under which plowing is not possible A large part of the pastureland in the United States is permanent, and rightfully so, since there are many acres on hillsides and lowlands that should never be broken up but should return a profitable acre income when in pasture and cared for properly

The best permanent pasture grasses and legumes vary in different sections of the country Kentucky bluegrass is probably

[*] *U S D A Tech Bul* 465

the most universal crop. The many others that are used include Canadian bluegrass, redtop, brome grass, timothy, orchard grass, carpet grass, Bermuda grass, Dallis grass, rye grass, fescue, white or Dutch clover, alsike clover, bur clover, hop clover, lespedeza, bird's-foot trefoil, and ladino clover.

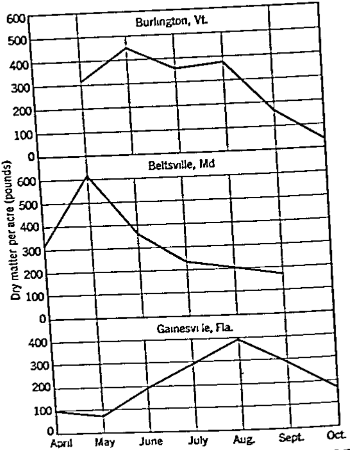

FIG 22. Monthly yields of pasture in different areas (*from U.S D.A. Misc Pub 194*)

A mixture consisting of both grasses and legumes is desirable Also, a mixture containing early growing and late growing crops will help to spread out the feed supply more evenly over the entire grazing period The crops should be selected from the ones best adapted to the specific locality.

Management of Permanent Pasture

The amount of pasture that can be secured from a given area of permanent pasture depends largely upon the management that it receives The pasturelands in most sections of the United States have been greatly depleted, and it is necessary that they be built up again if the greatest returns are to be derived from them

Proper Grazing Methods. Overgrazing is one of the chief causes of the depletion of pastures The effect of close grazing depends on the crops used for pasture The legumes and tall grasses cannot stand as close grazing as the shorter, more spreading crops The reduced leaf area lowers the ability of the plant to grow and to store nutrients in the roots Under these conditions the yield is lessened and the stand or covering becomes thinner because of the plants dying out The effect is greatest in periods of low rainfall or in arid regions

Undergrazing also has some undesirable effects Experiments at the Virginia Experiment Station [*] show that, with well established bluegrass pastures, comparatively closely grazed plots gave a higher yield than lightly grazed plots At the end of 3 years, it was found that the sod on the closely grazed plots was in a much better condition, with fewer weeds, than the sod in the lightly grazed plots When pastures are not kept grazed down, many heads form, and the pasture loses in palatability It should be pastured close enough to keep it from heading

Cattle should not be turned on pasture until after it has made a good start in the spring, and they should not be pastured too late in the fall

Alternate vs Continuous Grazing When dairy cows are kept in the same pasture throughout the entire pasture season, it is often difficult to get the pasture grazed uniformly, as the cows consume the pasture near the barn and leave that away from the barn until it has become too ripe In order to secure more uniform grazing and to give the pasture a chance to grow, a system of dividing the pasture into two or more separate fields and pas-

[*] *Va Exp Sta Bul* 204

turing the animals in succession has been advocated. By this system the cows are turned on the pasture when it is 4 or 5 inches tall and still palatable As soon as the cows have eaten the pasture down, they are turned into the second pasture If they cannot keep all the pastures eaten down, one field may be mowed for hay or silage, to prevent the bad effects of undergrazing.

HOHENHEIM SYSTEM The Hohenheim system, an intensive system of pasture fertilization and management in which alternate grazing plays an important part, has been developed in Germany The system consists of dividing the pasture into four or five fields, the size depending upon the size of the herd About 1 to 2 acres are allowed for each 10 cows Each field is fertilized with phosphorus and potash when needed, and particularly with liberal amounts of nitrogen each year in one or two applications The cattle are rotated progressively from one field to another at intervals of about a week. The young stock and dry cows are kept separate from the milking herd They follow in each field as the milking herd advances, eating the remaining and less palatable grasses In this manner each field is pastured when it is from 4 to 5 inches high, and is eaten completely so that it does not head out If the cattle cannot eat all the pasture fast enough, one field is mowed when 4 or 5 inches high so that the entire pasture will be kept palatable and not allowed to go to seed and die down A harrow is run over the pasture at intervals to scatter the droppings

the difficulty of maintaining white clover in the herbage" This system has not as yet gained wide popularity in the United States

Pasture Fertilization. Pastures usually respond remarkably well to fertilization They cannot be expected to maintain their yield year after year unless some plant food is added to replace that which is removed by the growing crop If fertilizers of some kind are not added, the yield of pasture gradually decreases until the pasture becomes unprofitable One should always realize that a pasture should be treated like any other crop, and should not be expected to produce a crop year after year without any fertilizer

The fertilizer treatment for a pasture varies greatly, depending upon the type of soil and its previous treatment If the soil is acid, a certain amount of lime must be added before other fertilizer treatments will be of much benefit On most types of soil, phosphorus is the limiting factor, but often potash will have excellent effects Whether or not these fertilizers will give good results depends largely upon the amount of these elements in the soil, but many experiments have shown that most soils will respond to these fertilizers This type of fertilization will not only increase the amount and growth of the grasses but will also encourage the growth of white clover and other legumes which are beneficial in adding nitrogen to the soil

If the acreage is low, so that it is desirable to increase the yield, it is often advisable to add some nitrogen fertilizer This is usually added at least twice during the season Nitrogen fertilization results in a much greater yield of grasses, but usually there are fewer legumes It will bring on the pasture in the spring about 2 weeks earlier than normal Such fertilization can often be practiced to advantage when used with heavy-milking dairy herds but cannot be relied upon to give yields during the dry season of the year The question as to whether it is profitable to fertilize pasture has been asked by many dairymen A study made at the Pennsylvania Experiment Station * has attempted to answer this question under the conditions as found in central Pennsylvania These results may not apply to all conditions but may indicate what might be expected from such treatments The results are given in Table XXXVI.

* *Penn Exp Sta Bul* 323

TABLE XXXVI

YIELD AND VALUE OF MILK, LESS COST OF CONCENTRATES AND FERTILIZER ON FERTILIZED PASTURE

(Acre Basis—Season of 1934)

Fertilizer Treatment	Pounds of 4 Per Cent Milk Produced	Value of Milk at $2 00 per Cwt.	Cost of Concentrates at $1.50 per Cwt	Cost of Fertilizer	Returns above Cost of Concentrates and Fertilizer
Lime	755	$15 10	$3 13		$11 97
Lime and phosphorus	1576	31 52	5 66	$ 1 92	23 94
Lime, phosphorus and potassium	1471	29 42	5 67	3 17	20 58
Lime, phosphorus, potassium and nitrogen	1643	32 86	5 87	5 51	21 48
Lime, phosphorus, potassium and nitrogen (put on at 2 times)	1001	21 82	4 49	5 75	11 58
Lime, phosphorus, potassium, 2 nitrogens	2161	43 22	8 83	7 97	26 42
Lime, phosphorus, potassium, 2 nitrogens (put on at 2 times)	1735	34 70	7 12	8 15	19 43
Lime, phosphorus, potassium, 3 nitrogens (put on at 2 times)	2236	44 72	9 34	10 45	24 93

The data indicated that a satisfactory return was made for money expended for fertilizer in all treatments but one The second application of nitrogen brought little or no return because of extremely dry weather which continued for several weeks

In an experiment with milking cows at the Virginia Station * covering a period of 10 years, permanent bluegrass pasture was limed and fertilized with phosphorus, phosphorus and nitrogen, and phosphorus and potash. A comparison of the average yields is given in Table XXXVII

It can be seen that the addition of fertilizer had a very great effect upon the yield

A similar experiment † of 10 years' duration was conducted in

* *Va Exp Sta Bul* 414 (1948)

† *W Va Exp Sta Bul* 324 (1945)

TABLE XXXVII

AVERAGE POUNDS OF TOTAL DIGESTIBLE NUTRIENTS PRODUCED PER ACRE WHEN NO FERTILIZER WAS APPLIED AND WHEN IT WAS FERTILIZED WITH THREE TYPES OF FERTILIZER

	Total Digestible Nutrients per Acre	Per Cent of Check Lot
Check	1245 1	100
Phosphorus	1759 3	141
Phosphorus and potash	2047 4	164
Phosphorus and nitrogen	2166 9	174

TABLE XXXVIII

AVERAGE STANDARD COW DAYS PER ACRE AND EQUIVALENT CARRYING CAPACITY IN ACRES PER COW UNDER VARIOUS FERTILIZER TREATMENTS

	Standard Cow Days per Acre	Carrying Capacity Acres per Cow *	T D.N Produced per Acre, pounds
Check	43 3	4 15	693
Phosphorus	65 9	2 75	1055
Phosphorus and potash	83 9	2 15	1393
Phosphorus, potash, and nitrogen	94 5	1 90	1513

* Acres required to carry an average producing cow for 180 days

West Virginia, the results of which are given in Table XXXVIII All plots were limed

In another study with milking cows at the Virginia Station * results were secured on the residual effect of two large applications of fertilizer on consecutive years without further fertilization The fertilized lot was limed It had an application of 1000 pounds of 8–8–8 fertilizer each year for the first 2 years (Table XXXIX)

The drought year of 1930 gave very poor results The next year the residual effect was quite marked and the fertilized lot almost doubled the carrying capacity of the check lot. With no more fertilizer added, the production declined steadily for the

* *Va Agr Exp Sta Bul* 309 (1937)

TABLE XXXIX

Days of Grazing and Nutrients Produced per Acre

Year	Pounds 8-8-8 Fertilizer	Fertilized Days	Fertilized T D N. Pounds	Unfertilized Days	Unfertilized T D N. Pounds
1930	1000	54	982	30	611
1931	1000	218	3266	112	1802
1932	0	138	2313	83	1403
1933	0	126	2287	89	1603
1934	0	118	1908	92	1578
1935	0	97	1725	68	1251
1936	0	65	1110	63	1035

following 4 years At the end of that period the fertilized lot was still producing slightly more than the check lot and during the 6 years had produced 46 per cent more nutrients Although the yields indicated that the residual fertilizer had largely been used up by 7 years' grazing, the sod was superior in density, and contained fewer weeds than at the beginning of the experiment.

The type of fertilization and the amounts and the time of application will be dictated by the needs of the specific soil and other local conditions

Specialized Pastures

The most intensified pasture systems in the world are probably the Hohenheim system developed in Germany (referred to earlier) and the intensive pasture system in New Zealand

In this country some dairymen in practically every dairy section are growing specialized pasture crops and treating them more like their other main crops Yields are obtained that compare favorably with any forage crop Pastures used in these intensive programs must receive heavy applications of fertilizers and be managed differently than the usual permanent pasture

Crops to Use in Intensive Pastures Program. The crops to use in intensive pasture programs must be heavy feeders and produce rank growth quickly Some of the more popular ones are ladino clover, alfalfa, orchard grass, brome grass, and fescue These plants have different adaptations and all do not do their

best at any one location. Also, there are others that respond well at certain locations, including alsike clover and bird's-foot trefoil.

Ladino Clover is a giant strain of white clover. It requires heavy fertilization and considerable moisture. It is probably the most productive pasture crop for areas of heavy rainfall and irrigated sections. Ladino cannot be grazed continuously but is used in a rotational grazing system. The pasture yield is greater when ladino is grown with one or more of the grasses. When grown alone there is danger of bloat. The greatest value of ladino is for pasture. It is seldom made into hay because it is so difficult to cure. Excess growth is often used for grass silage.

Alfalfa has generally been grown for hay only. It will, however, furnish an abundance of pasture. Like ladino, it should be grown in a mixture with grasses. These two crops are two of the foremost milk-producing pasture crops. Alfalfa pasture must be rotated, since it will not stand continuous grazing. It will not maintain its stand as long as ladino.

Orchard Grass is productive and grows early in the spring and late in the fall. It responds well to heavy fertilization and if seeded in combination with alfalfa or ladino has a tendency to crowd them out. It can be kept in the desired proportion, however, by clipping after the rotational grazing period.

Brome Grass is used extensively in the northern and central part of the country. It grows well with alfalfa for either pasture, hay, or grass silage. Brome yields well but is not well adapted to the southern area.

Fescue is a grass of many varieties and uses. Kentucky 31 fescue gives an abundant growth and holds on well into the fall and winter. It is not so palatable and has some limitations when used in mixtures. Usually, a mixture of one or both of the legumes with one or two of the grasses is used. The specific mixture will depend upon the adaptation of the legumes and grasses.

Value. The value of these pastures is manifold. (1) The carrying capacity is high: sometimes they carry a cow per acre. (2) The best pastures will graze a cow per acre with surplus pasture during spring or early summer to make into silage or hay. (3) A more even feed supply is furnished throughout the year.

(4) These crops, well fed and properly managed, will start earlier in the spring, maintain more growth during the summer, and continue later in the fall than the usual permanent pasture. (5) With more grass available in a limited area, cows will consume more nutrients and maintain their production at a higher level.

Permanency. There is a limit to the length of time that these mixtures can be maintained. The probable life may be given as 6 to 10 years The mixture may change as one of the crops gives way to or is crowded out by the other

Management of Pastures. In some parts of the country, especially in the East, heavy applications of as much as 500 to 800 pounds of fertilizer per acre each year are applied Nitrogen fertilizer will favor the grasses and may cause them to increase at the expense of the clovers Fertilizers also favor the growth of weeds as well as grass so that such pastures must be kept mowed In many of the newer sections, such heavy fertilization is not necessary

Rotational Grazing. Pastures consisting of one of the grasses with a legume should be grazed in a rotation system, since they will not stand continuous grazing because of the nature of their growth By this system, the cows are turned on a small area of pasture when it is 4 to 6 inches tall and still palatable As soon as they have eaten the pasture down, they are turned into the second lot, and so on Electric fences are valuable for dividing pastures into smaller lots. If the cows cannot keep all the pasture eaten down, one or more of the lots may be mowed for hay or silage to prevent the bad effects of undergrazing The pastures should be kept mowed in order to keep down the weeds In addition, a light harrowing will scatter the droppings

Some New Zealand dairymen * have gone a step farther and practice "rationed grazing." This system is based on a change of pasture for the herd every night and morning after milking, grazing a very small acreage completely from one milking to the next.

* *Hoards' Dairyman* (July 10, 1951)

Temporary Pastures

A temporary pasture lasts for only 1 or 2 years and is designed to carry stock only for such a period. On account of the large amount of work necessary to prepare the ground and to sow the seed, this type of pasture has not been used extensively in the past in many parts of the United States. In some sections, however, temporary pastures are now being widely used. Their advantage is that the yield is very much greater than that of a permanent pasture, and that they may furnish pasture during the so-called dormant period of bluegrass and other permanent pastures.

Sweet clover has been highly recommended for a temporary pasture. It is a biennial and seldom blossoms the first year. It may or may not be sown with a nurse crop in the spring and is often pastured to some extent the following late summer. During the first season, little return can be anticipated from a sweet-clover pasture, but during the second year the yield will usually be extremely good, especially in the early part of the season. It has the disadvantage that in at least part of the country its greatest yield comes at the time of year when the permanent pasture is at its best, and hence it is not a good supplement for these pastures. It has a bitter taste and, until the cows become accustomed to it, some trouble is experienced in getting them to eat it. Bloat is sometimes caused by pasturing cows on sweet clover.

Sudan grass is one of the most popular temporary pastures, as it can be planted so as to fit into the time when most needed. Since it is drought resistant and is a warm-weather plant, it should not be planted until the ground has warmed up well in the spring. It is a nonlegume, and is often grown with soybeans. Sudan grass does not cause bloat like sweet clover, but occasionally, especially when the growth has been stopped by drought or by frost, prussic acid poisoning results with the pasturing of Sudan grass. It is important to use certified varieties to minimize the hazard of poisoning. Sweet varieties of Sudan have been gaining in popularity. They are very palatable and are not subject to some of the diseases of the common varieties.

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Other crops that are used in various parts of the country for temporary pastures are oats, field peas, millet, and lespedeza. All these have been used successfully. The aftermath of red clover or clover and timothy hay crops may also be used for pasture during late summer months.

Comparison of Alfalfa, Sweet Clover, and Sudan Grass. The South Dakota Station * has made a study of alfalfa, sweet clover, and Sudan grass as a pasture for dairy cows. Table XL shows

TABLE XL

MILK AND BUTTERFAT PRODUCED PER ACRE PER DAY PER SEASON BY COWS PASTURED ON ALFALFA, SWEET CLOVER, AND SUDAN GRASS

	Alfalfa		Sweet Clover		Sudan Grass	
Year	Milk, pounds	Butter-fat, pounds	Milk, pounds	Butter-fat, pounds	Milk, pounds	Butter-fat, pounds
1927	40 2	1.48	50.4	1.83	*	*
1928	22.6	0.97	28 3	1.19	46.2	2.00
1929	35.7	1.64	43.7	1.83	39.8	1.82
1930	55 2	2.29	*	*	56 3	2.26
1931	40.9	1.65	58.1	2.22	*	*
Average	38.9	1.61	45.1	1.76	47.4	2.03

* No pasture available.

the amount of milk and butterfat produced per acre per day per season by each of these crops.

Under the conditions found in South Dakota, Sudan grass, though a short-season crop, produced more pasture for the time it was used than either alfalfa or sweet clover. It did not, however, furnish as many pasture days.

As a supplementary pasture, it has the advantage over sweet clover of furnishing the pasture when needed. During the season, however, it will not produce as many pasture days as sweet clover. Three years' trial at the West Virginia Station, Table XLI, shows that sweet clover furnishes most of its pasture during the early months and Sudan grass furnishes it in the latter part of the season.

* S. D. *Agr Exp Sta Bul* 265

TABLE XLII

PERCENTAGE OF TOTAL DIGESTIBLE NUTRIENTS OBTAINED FROM RYE GRASS AND CRIMSON CLOVER PASTURE EACH YEAR, AND THE AVERAGE FOR 3 YEARS, BY 28-DAY PERIODS

Dates	28-Day Periods	1946–1947	1947–1948	1948–1949	Three-Year Average
Dec. 2–29	1	5.3	10.2	11.1	9.6
Dec. 30–Jan. 26	2	10.6	7.5	7.9	8.3
Jan. 27–Feb. 23	3	14.7	5.9	8.0	8.6
Feb. 24–Mar. 23	4	7.3	18.9	11.7	13.5
Mar. 24–Apr. 20	5	25.1	30.2	22.3	25.8
Apr. 21–May 18	6	37.0 *	24.3	27.9	28.4
May 19——	7	.....	3.0 *	11.1 *	5.8 *
Total		100.0	100.0	100.0	100.0

* The last entry in each year is for less than a full 28-day period.

until the latter part of May. The data are given in Table XLII.

Although the heaviest growth was in April and May, considerable feed was furnished from December to March inclusive. There was a total of 167 days of grazing.

Table XLIII gives the production of milk and the amount of feed consumed by two groups of cows. One group was entirely barn fed and the other group was grazed on rye grass and crimson-clover pasture for a portion of their feed.

The group that was grazed averaged 22 per cent more milk than the barn-fed group and consumed only 54 per cent as much barn-fed nutrients as the other group.

TABLE XLIII

THREE-YEAR AVERAGE FEED CONSUMPTION AND FEED REQUIRED FOR 100 POUNDS OF 4 PER CENT F.C.M. ON WINTER PASTURE (SOUTH CAROLINA EXPERIMENT STATION)

Group	Feed Fed			Average Milk Production, pounds, 4 Per Cent F.C.M.	*Feed Required for 100 Pounds 4 Per Cent F.C.M.*		
	Concentrates	Hay	Corn Silage		Concentrates	Hay	Corn Silage
Control	9.3	17.1	32.5	29.7	31.2	57.4	109.1
Grazing	9.6	9.8	....	36.3	26.5	27.4	....

Value. Most of the winter pasture comes from annuals. The cost of preparing the land, seeding, and fertilizing, makes it more expensive than summer pastures. The value is determined not by comparing it with summer pasture, but by the value of the barn feeding that it replaces. Also, cows that have access to pasture are usually better-fed animals.

Soiling Crops

The practice of cutting green crops and feeding them in that condition is termed soiling. This is a common custom in Europe. It is not practiced extensively in this country, except for short periods of time when pastures are short.

Most any of the high-yielding forage crops are suitable for soiling crops. By their use large tonnages of feed can be grown per acre.

The labor required to harvest and feed a soiling crop each day is such a great disadvantage that few dairymen of the United States have used them, except in the specialized dairies of California. However, with the more extensive use of field choppers, this program is finding more favor.

Use of Surplus Pasture

Whenever sufficient grass is produced for the greater part of the pasture season there will be a surplus during the heaviest growing period, mainly in the spring and early summer. If this surplus grass is allowed to mature, the pasture will lose much of its milk-producing value. The amount of pasture that is not needed for grazing at this period should be fenced off by electric fence. This can be cut for either hay or grass silage. This method gives added acreage to graze at other times of the year.

BLOAT

Bloat in cattle, which sometimes occurs when animals eat green lush legumes, has caused trouble when ladino clover, sweet clover, alfalfa and some other legumes are pastured. There are certain recommended management practices that will help

minimize this trouble. The general recommendations are: to seed a mixture of grasses and legumes instead of a pure stand of legumes, to have water available in the field, or nearby; to have cows filled with grass hay when they are turned on the pasture for the first time (a stack of grass hay may be placed in the pasture field); and for the first few days allow the cows to graze for only an hour or two, to accustom them to the new feed.

The stems of grass or hay exert a tickling action on the lining of the rumen and stimulate the passage of excess gas through the esophagus Legume leaves tend to form a very soft slimy mass that will not stimulate activity of the rumen wall.

IRRIGATING PASTURES

The growth of pasture grasses is more dependent upon moisture than any other single factor. Irrigating pastures from water

Fig 23 Irrigating pastures (V P I)

supplies such as ponds, creeks, and rivers is receiving much attention When the value of the extra feed is calculated on the basis of the cost of barn feeding that it replaces, it appears that the practice is profitable under some conditions

Irrigation trials of 3 years' duration conducted at the Tennessee Experiment Station * resulted in 33 per cent more cow days of grazing and 35 per cent more milk produced on irrigated pasture than on similar pasture that was not irrigated The cows on irrigated pasture returned 27 per cent more profit above feed and irrigation costs than the other group

FEEDING COWS ON PASTURE

As previously noted, pasture is not a concentrate and it is impossible for heavy milking cows to consume sufficient pasture to furnish the necessary nutrients for their milk production As a result, such cows will decline rapidly in their milk production after the flush of the pasture is off, unless they are given some feed along with their pasture Even the best pastures will furnish only enough nutrients for cows producing from 30 to 40 pounds of milk per day, so that it is necessary to recognize this fact and to supply the cows with additional feed before they drop too rapidly in milk production After cows once decline in milk production it is difficult to get them back, hence, less milk will be produced during the entire lactation When the permanent pasture begins to decline, it should be supplemented with temporary pasture, silage, soiling crops, or good hay in addition to a grain mixture in order to maintain the milk production

The economy of feeding grain to cows on pasture was studied † with cows being grazed on good bluegrass pasture and limited ladino clover The cows were in various periods of lactation and the experiment covered a 4 month period

There was some profit in grain feeding even when grain was charged at $3 00 per hundred pounds and milk was valued at $3 00 per hundred pounds At the end of the 4 month period the no grain group was producing less than two thirds of the production of those fed grain The greater reduction in production of the no grain group would be reflected in later winter production which would further contribute to the advantage of feeding grain and offset the cost and labor of feeding

* *J Dairy Sci*, 31 696 (1948)
† *Va Agr Exp Sta Bul* 428 (1950)

TABLE XLIV

THE ECONOMY OF FEEDING GRAIN TO COWS ON PASTURE. DATA FOR A 4 MONTH PERIOD

Group	Pounds Grain per Cow	Value of Grain at $3 00 per Cwt	Pounds Milk per Cow	Value of Milk at $3 00 per Cwt	Value of Milk at $5 00 per Cwt.	Value of Milk over Cost of Grain: Milk at $3.00 per Cwt	Value of Milk over Cost of Grain: Milk at $5 00 per Cwt
Grain	668	$20 05	3886	$116 58	$194 30	$96 53	$174 25
No grain	0	0	2785	83 55	139 25	83 55	139 25
Difference	668	$20 05	1101	$ 33 03	$ 55 05	$12 98	$ 35 00

The amount of grain mixture to feed will vary with the kind of pasture, the amount of milk that is being produced, and the test of the milk. A guide for feeding cows on pasture is given in Table XII, in Chapter 11

When the pasture is good, less grain is needed than when it is fair Supplemented with abundance of good hay, silage, or soiling crops, the pasture would be considered good, but if no such supplement is available, pastures will usually be considered only fair, after the flush is off in the spring Temporary pastures are usually classified as good pastures until they are pretty well eaten down It is usually unwise to feed grain in amounts above those indicated in the table Supplementary feeds of other kinds should be supplied if the cows are heavy milkers The amount of protein in the grain mixture for cows on pasture need not be high when the pasture is good Young pasture grasses and legumes are rich in protein. Hence, a grain mixture consisting of home grown grains and containing not more than 12 to 14 per cent protein can be fed with good results As the late summer approaches the pasture grasses contain considerably less protein, and at that time the protein content of the grain mixture should be raised to 14 to 16 per cent. It is seldom necessary to go over 16 per cent unless the pasture is very poor

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16

Some Details in Dairy Cattle Management

The man and the cow are the two most important factors in profitable dairying The man is responsible for the type of dairying that is carried on He may make it an interesting and profitable business or he may allow it to be a job of drudgery that returns little for his work

A good herdsman is not only a lover of good cattle but also one who has the "know how" and the ability to get the job done There are times when he places the comfort and well being of his cattle above his own desires The pay off job in dairying is milking The man handling the herd must be a good milker, furthermore, he must see the entire job from the standpoint of having the herd well cared for and managed in a sound financial way

HANDLING THE HERD

Regularity of Care. The dairy cow is a creature of habit The same routine of feeding milking, and caring for her should be used each day It is desirable that the cow have approximately the same amount of exercise, and that she be fed and milked at the same hour and in the same manner daily No system is stronger than its weakest link A change of milkers or even a strange feeder or other persons in the barn has an effect upon some of the more sensitive animals Most cows can, however, become accustomed to a certain amount of change

Kindness in Handling A cow must always be treated with kindness if she is to maintain production The beating of a cow should never be tolerated under any circumstances It is not

only cruel but it reduces milk production A man who cannot control his temper will never make a good dairyman Many good herdsmen can go into the field or lot where his cattle are loose and pet or catch them without trouble, but when animals are handled roughly they will run away from their caretaker When they are handled gently and quietly they will go in and out of the barn slowly with less disturbance or danger of injury Dairy cows should never be hurried in going to or from pasture or while in the pasture Seldom do dogs have a place in handling dairy cattle, since most dogs will move the animals too fast Dogs around the barn at milking time may disturb the herd to such an extent that not only the quantity of milk but also its composition will be affected

Exercise Dairy cows need only a limited amount of exercise The work that they do in eating, chewing, and digesting their feed gives them considerable activity Time studies on cows show that they spend from 9 to 15 hours out of each 24 lying down They do their eating and a part of their ruminating while standing, but most of their ruminating is done while lying down They chew each cud 50 to 55 times at the rate of about one chew per second The time between swallowing and regurgitating the next cud is from 5 to 10 seconds

When cows are housed by the loose housing method the free dom of movement will suffice Some herds that are producing well are kept in stanchion barns throughout the winter In gen eral, however, it seems desirable to give the animals at least some exercise, as they seem a little more thrifty and maintain a better appetite when they are allowed to exercise A general routine is to turn them out for as much of the day as the weather will permit Usually, they can be turned out for at least an hour or two while the barn is being cleaned This enables the dairymen to do the cleaning to better advantage and at the same time gives the animals a certain amount of regular exercise This will keep them from getting stiff and possibly lame from being confined too long

It is possible for a dairy cow to have so much exercise that she will use up energy unnecessarily This is true when she is driven too far to pasture or when the pasture is so poor that she must cover too much ground to get enough feed In extreme cases,

when cows are used for work animals the amount of milk is reduced and the milk solids especially the fat content are lowered

Grooming Dairy Cows Dairy cows should be groomed daily, especially in winter It is necessary to remove dirt and loose hair from the cows for the production of clean milk The appearance

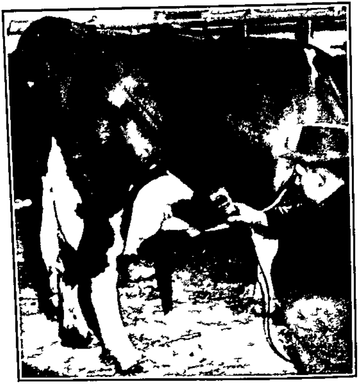

FIG 24 Clipping the long hair from the flank and udder of a cow makes clean milk production easier (*W Va Univ*)

of the cows too should be in keeping with good care of the cattle and sanitary milk production methods Grooming keeps the skin clean and stimulates circulation which makes the hide and hair smoother and more pliable This causes the animal to show more quality and better condition

The equipment needed for grooming is a blunt type curry comb for removing the coarse material or manure from the cow and a heavy bristle brush for the main grooming job The comb should be used gently so as not to irritate the hide Some herdsmen like a rubber currycomb It is easy on the hide and is a

good tool to remove loose dirt and hair. It is not satisfactory on soiled areas. There is an electrically operated, revolving bristle brush on the market that does a satisfactory job of grooming cows, except on wet areas.

Clipping. One of the greatest aids in keeping milking cows clean is to clip the belly, udder, and the rear portion of the animal, including all area back of a line from in front of the udder to the tail head. Clipping this area removes the long hairs where the cow is most likely to be soiled when she lies down. Bedding and manure will not adhere to short hair to the same extent as to long hair. Any that does is easier removed.

This type of clipping is different from that used for fitting cattle for a show or sale. The purpose is different and the area to be clipped is determined by the part of the cow that has to be cleaned the most.

Dehorning

Cows in commercial herds should be dehorned. This statement should probably include all dairy cattle. A few breeders, however, retain the horns on their cattle for sale and show purposes. This is more common with Jersey, Ayrshire, and Guernsey breeders than with Holstein and Brown Swiss breeders. It is questionable today whether the horns on dairy cattle are as important in the shows and sales as some breeders seem to think. The dairy cattle score card, as approved by the Purebred Dairy Cattle Association, does not discriminate against the absence of horns if the animal has been cleanly and neatly dehorned.

Cows with horns endanger one another, especially by injuring the udder, ramming cows against posts, and knocking down hips. Dehorned cows can be kept together in closer quarters or yards without danger. They can be fed together with more uniform consumption of the feed by all animals. They will be quieter, which allows them to make better use of their feed.

There are polled strains in each of the dairy breeds. They have been developed to bring about a hornless condition, without the operation of dehorning. This is certainly a desirable characteristic. In selecting foundation animals, however, all inherited

characteristics must be considered and those of more commercial value should not be sacrificed in order to get the polled character

Methods of Dehorning The horns may be removed from the young calf by the use of caustic, other chemicals, or with an electric dehorner When the calf is 2 or 3 months of age a gouge or a Barnes dehorner can be used Older cattle can be dehorned with horn clippers or a saw

Removing Horns with Caustic This method destroys the horn cells in the buttonlike rudiments of horns on the calf before it is 10 days old A stick of caustic potash (potassium hydroxide) is used The hair around the buttons should be clipped close and a ring of grease, such as vaseline, put around the button to protect the surrounding skin from the caustic The caustic stick should be slightly moistened and rubbed over the button until the skin begins to slip and blood appears This should be carefully and completely done, otherwise, some of the horn cells may not be destroyed and a scur, or small abnormal horn, may develop The caustic should be wrapped in a paper to protect the operator's hands In a week or 10 days the scab that forms should drop off A caustic paste may be used instead of the caustic stick The same procedure is used except the paste is applied to the button with a small paddle and left on it This paste is available in the form of various commercial products

Removing Horns with Other Chemicals Workers at the Wisconsin Station [*] reported effective dehorning with a solution containing antimony trichloride salicylic acid and collodion This should be used on the calf by the time it is 10 days of age Commercial preparations of this mixture and others are available on the market

Electric Dehorners The electric dehorner is relatively new LaMaster of Clemson College did some of the first work in developing it The dehorner is designed similar to a high temperature soldering iron with the iron being round and hollow at the end The iron is heated to a temperature of 900 to 1000°F The end is placed over the horn to destroy the horn producing cells at the base of the button This requires 5 to 10 seconds

[*] *J Dairy Sci* 31 693 (1948)

The side of the dehorner is then applied to the tip of the horn to complete the job.

Gouge and Barnes Dehorner. After calves are 2 or 3 months old the previous methods will not work. The horns are developing at this age but are not attached to the bony structure of the head. The gouge or Barnes dehorner can be used to remove the small horns. Considerable bleeding will follow but should not be dangerous. The advantage of this system is that the age range is greater, and more calves can be dehorned at the same time.

Clippers or Saw. After horns are partially or fully grown they can be taken off with horn clippers or a saw. Usually clippers are used on immature animals and a saw is used on mature cattle. The operation should take place when the animal is a long yearling or older. If done at an earlier age, stubs are likely to develop. The best time to remove horns is in the fall or spring. It should not be done during fly time or in cold, rainy weather unless the animal is well protected. Whichever instrument is used, the practice should be to remove the horn as near to the head as possible. When a ring of hair at the base of the horn is removed with the horn it is seldom that even a stub will grow. If there is considerable bleeding or if it is necessary to dehorn during fly time, it is advisable to cover the wound with pine tar or cotton soaked in pine tar.

To alleviate the pain, especially in older animals, an anaesthesia may be injected between the horns. With its use there is very little drop in milk production. Otherwise, there may be a slight drop for 2 or 3 days. When the dehorned animals are protected from extreme cold, wind, rain, and dust there are seldom any ill results from dehorning. It is a wound and can be infected; therefore, the protection indicated above should be given as needed.

Trimming Hoofs

Cows that are kept in the barn for several months often develop long and misshapen hoofs. When on pasture, cows usually keep their hoofs worn evenly and to a normal size. Some cows, however, appear to have hoofs so hard that they do not wear down. Other cows do not walk squarely on their feet and

wear their hoofs unevenly This is often true of cows that have foot rot.

The hoofs should be trimmed when they are too long or are uneven, otherwise the long toes may break off and cause lameness

The trimming should be done largely from the bottom of the hoof with a chisel pincers, hoof knife, and rasp Extremely long hoofs may be cut back on the front and side before the bottom is trimmed This may be accomplished with pincers, or the foot may be set on a solid board and cut with a chisel

Care must be taken not to cut too far back or too deep as there is danger of cutting into the quick, which may result in lameness and foot infection

The front feet of most animals and all feet of some animals can be trimmed without throwing the animal A stock for confining the animal and securing the feet firmly makes the job much easier and a better job is done

With some bulls and cows it is necessary to throw them and tie their feet securely The throwing is easily accomplished by the use of a long rope used to make two half hitches around the body

A cow that cannot walk well will not do her best in milk production A bull with long and misshapen toes may have difficulty in serving cows

Watering

Dairy cows must consume large quantities of water for the production of milk. The amount that a cow will drink depends largely upon the outside temperature the kind of feed eaten the amount of milk the cow is producing and the temperature and cleanliness of the water A large cow producing 25 to 30 pounds of milk daily and eating both dry and succulent feeds will easily drink as much as 100 pounds of water per day The Idaho Experiment Station * found that, under ordinary conditions dry cows consumed 73.5 pounds of water per day medium producing cows (30.2 pounds of milk) consumed 109 7 pounds per day and heavy producing cows (82.4 pounds of milk) consumed 191 4

* *J Dairy Sci* 17 265

pounds per day. It is apparent that a large amount of water is necessary even for dry cows. The importance of having water before the cows at all times can easily be seen.

A cow will not drink all the water she needs for the most profitable production of milk unless she can get it frequently, without discomfort, and at a temperature not below that of well or spring water. Many dairymen are using automatic drinking cups in their barns in order to supply these conditions.

Some persons have believed that soft water was more desirable than hard water. Studies at the Virginia Station * showed no difference in water consumption or in milk production of cows from the use of either soft or hard water.

If the weather is warm, more water is required than in moderate or cold weather. Cows will drink up to twice as much water in hot weather as in cold winter weather. Since cows do not sweat, or, if so, relatively little, they eliminate more water as urine in hot weather in order to cool the body. If the feed is of a succulent nature, the cow will consume less water than if she were fed dry feed.

In experiments at the Beltsville Station,† average-producing cows were watered once a day, twice a day, and at will from watering cups. The cows watered once a day drank less and produced less than those watered twice a day, and the cows watered twice a day drank as much but produced less than those watered at will. It was found that the higher the production the greater the benefit derived from frequent watering. The cows consumed about 4 pounds of water for each pound of dry matter consumed.

The Iowa Station ‡ found that dairy cows watered by means of water bowls in the barn consumed approximately 18 per cent more water and yielded 3.5 per cent more milk and 10.7 per cent more butterfat than cows watered twice per day at an outside tank. Cows in the barn drank an average of 10 times per day, consuming two-thirds of their water in the daytime and the other third at night (5 P.M. to 5 A.M.). The cows watered outside twice per day in very cold weather drank only once per

* *J. Dairy Sci.*, 35:998.
† *Farmers' Bul.* 170.
‡ *Iowa Exp. Sta. Bul.* 292.

day about 30 per cent of the time The amount of water consumed was about 3.0 to 3.5 pounds of water for each pound of milk produced

In cold weather the cows will drink more water if it is slightly warmed The economy of this practice depends on the climate Ordinarily, if water is given in the barn at will, either in watering cups or in a tank, so that they can drink small quantities at frequent intervals, no advantage will result from warming it

The size of the water tank needed depends on the number of cows to be watered, how often they have access to it, its rate of supply, and the number of times the tank is to be filled each day

If the tank is to hold a day's supply, 15 gallons per cow should be allowed When cows are watered twice a day, allowance should be made for 10 gallons capacity per cow, except where the water is replenished quickly Where cows have free access to the water tank, a float valve can be used to keep the water level constant A small tank will suffice with this arrangement One cubic foot of water is approximately 7½ gallons

A water tank, no matter where it is located, needs a paved apron around it Otherwise, a mudhole is almost sure to develop

The availability of abundant water in summer is even more important than it is in winter It is, however, more often taken care of automatically Springs and streams in pastures are valuable assets The cow should have access to water continuously and at not too great a distance

THE DRY COW

Three methods of drying off the cow are in use namely, incomplete milking, intermittent milking, and complete cessation A study at the Minnesota Experiment Station * showed that complete cessation of milking can be recommended safely with cows producing as much as 20 pounds of milk daily Cows were dried off in less time with this method than with the other two, and no significant differences were noted in the quantity and quality of the milk in the following lactation In drying a cow by this method, the udder fills until pressure great enough to stop secre

* *J Dairy Sci*, 16 69

tion is developed in the udder. After secretion stops, the milk is gradually resorbed from the gland until it becomes dry. The cow should not be milked during the resorption period as this releases the pressure within the gland and secretion is again initiated, resulting in a prolonged period of drying off.

Care of Dry Cow

The dry cow may be allowed to continue to run with the regular herd. Often her stall is needed, however, and dry cows are handled in another barn. Either method is satisfactory, so long as she is handled and fed to condition her for freshening.

When close to calving time, the cow should be isolated from the remainder of the herd. This can be done in a clean, well-bedded stall or in warm weather in a separate pasture or lot. By use of the breeding date and a gestation chart the herdsman can know about when to expect the cow to calve. There are, of course, variations from the average.

As the cow nears calving time the udder will fill up and the teats will become distended. When there is much swelling (edema) in the udder, it usually begins at the bottom and moves upward. This is especially noticeable on the rear udder. By calving time this swelling will extend up next to the body of the cow. Other indications are the swelling of the vulva and the relaxing of the muscles around the tail head and the pin bones. The cow usually shows restlessness and in a field will seek out an isolated place.

The majority of cows will not need any help with calving. However, occasionally they do need help. An alert herdsman will keep an eye on the cow but not disturb her unless she shows evidence of needing help or delays calving too long after labor begins. The heifer with her first calf is slower in calving than an older cow. Immediately after calving the cow will be thirsty from loss of fluids, and she should be allowed to drink a quantity of warm water and in cold weather to eat a warm bran mash. These will warm her system and stimulate her. It is thought to help expel the afterbirth or placenta. Drinking cold water or chilling from drafts or lack of protection tend to cause the retention of the afterbirth.

When the afterbirth is passed it should be removed from the stall In the state of nature the cow consumed the afterbirth The reason for this instinct is that in the wild state, with poor nutrition, the cow may have needed the nutrients in the after birth Also, she may have cleaned up any evidence of the new birth to prevent attack by maurauding animals There is no evidence to prove that the modern cow needs to consume the afterbirth

IDENTIFICATION OF CATTLE

It is necessary to have some means of designating and identifying the animals in a herd Many dairymen name their cows but do not have identifications except as they know them This may work very well in herds so small that one can keep in mind all the animals In larger herds and in all purebred herds it is never safe to depend on memory Some method of marking must be used

Animals can be marked and identified by eartag, tattoo, number tags attached to straps or chains around the neck or horn chains, branding numbers on horns or hips, ear notches, photograph, or by color sketches

For Registration Purebred animals to be registered must have a permanent identification Color markings, which do not change with age, are used by some of the breeds The spots on the broken-colored animal can be sketched on a cow outline, or a photograph may be taken With solid-colored breeds, a tattoo in the ear is required

Eartag The most common method of marking and identifying dairy cattle is by metal eartags placed in their ears These tags have numbers or numbers and letters stamped on them The standard Dairy Herd Improvement Association method of identification is the eartag The calf is eartagged by the Dairy Herd Improvement Association supervisor when it is a month or less of age and its identity recorded Practically all cattle that are tested for Bang's disease or tuberculosis are eartagged The few exceptions are registered cattle that have registration papers available for identification

Tattoo. Animals with light-colored ears can be tatooed in the ear. The tattoo does not show too clearly in black colored ears. The method is to punch several small holes with a die in the form of numbers or letters through the skin on the inside of the ear and then fill them with tattoo ink. If done correctly, this is a permanent mark. Its disadvantage is that the animal must be caught and the inside of the ear cleaned to be able to read the identifying marks.

Number Tags. Metal tags, large enough to be read at a distance, are quick means of identifications. They may be fastened to a neck strap or to horn chains. There is a chance that they may be lost. A chain can be fastened with a padlock.

Branding. Branding numbers and letters on the horns or on the hip can be done with either branding irons or a branding fluid. This method is seldom used with dairy cattle.

Ear Notches. Notches cut in the ears make a rather easy method to identify animals. A notch represents a number depending on its location, whether in the top, bottom or end of the ear, and also, which ear it is in. Few dairymen are willing to disfigure the ears of their cattle in this way.

VICES OF COWS

Cows may develop certain habits that range all the way from being a nuisance to rendering the animal almost useless as a dairy cow. For example, occasionally there is a cow which cannot be left in the barn with a drinking cup with a paddle valve because *she will flood the barn.*

Sucking. Probably there is no more difficult problem to deal with than an animal that sucks another cow or herself. Often, there is much difficulty with calves sucking each other during the milk-feeding period. However, the problem is not limited to calves. Young calves can best be kept in individual pens or tied so that they cannot reach each other. With older heifers and cows, a more difficult problem prevails. Separating the animals concerned may be the easiest and most successful method if it can be done. Many patent devices are partially effective for overcoming this habit, such as muzzles with sharp prongs in them. Most of these require some attention. If they are used

on cows that suck other cows there is some danger of injury to the udder A simple method that is helpful in controlling sucking but not always effective, is to put a bull ring in the cow's nose and attach two or three other rings to it A special ring that has some sharp prongs soldered on to it is very effective The ring needs no attention and does not interfere with the animal s eating but does interfere when she attempts to suck. Many other devices have been tried but sometimes nothing will work.

Kicking Some cows develop the habit of kicking through improper treatment, whereas others are characteristically vicious Of the latter class, there are fortunately very few Practically always, if the animals are carefully handled, especially during the first days of milking of their first freshening, they will be quiet milkers Should they give difficulty, the teats and udder should be examined thoroughly for soreness and injuries Patience and kindness for a few days will pay dividends in quiet coöperative cows later Some cows do not respond and remain vicious If they are good producers and if it appears wise to keep them, they may be milked by securing them in various ways One method is to tie the head high Another is to tie a rope around the body of the cow just in front of the udder With many cows, after this method has been used several times, it may be necessary only to throw the rope over the back In severe cases anti kicking chains can be used A clamp fits over each hock and a chain fastens them together This gives the cow little freedom to kick Sometimes a piece of rope is used to tie the hocks together

Some men develop confidence in their cows and can get along in handling and milking them with little difficulty Others seem to keep the cow afraid and on the defensive In rare cases nervousness and viciousness may be inherited This is a character to consider in selecting cows for foundation animals

Fence Breaking Usually cows break, crawl through, or jump fences because they have little to eat within their boundary A few just seem to think the grass on the other side of the fence is greener There is little that will stop a roguish cow except good fences

ARRANGEMENT OF COWS IN THE BARN

There should be, if possible, a systematic method of arranging cows in the barn. Each dairyman can choose the arrangement that is best suited to his barn, the layout of his work, and the one that would be the greatest help to him in his work.

By Size. It is advisable to construct the dairy barn with stalls of varying lengths. The cows can then be lined up in the row according to size. With this plan it is best to have the young cows or smaller ones at the entrance end of the barn. They will learn their stalls more quickly than where they must go the full length of the alley past all the other stalls.

By Sires. Breeders of purebred cattle like to have all the daughters of a bull together. This is especially effective in showing animals to prospective buyers. When so grouped, they can be more carefully and thoroughly evaluated. Often, the different qualities of first-calf heifers by a sire will be more easily seen if they are together than if they are scattered throughout the barn. In a specific case, ten daughters of each of two bulls freshened about the same time. They were scattered throughout the barn and produced about the same amount of milk. Later, however, when they were grouped according to sires, a specific characteristic became evident. The group by one sire had more quality in their udders and were easier to milk. This characteristic was much more evident when the young cows by different sires were milked by groups.

By Health of Udder. When mastitis is an active problem in a herd, the cows should be arranged according to the health of the udders. The clean, first-calf heifers should be milked first; then the older cows that have no history of udder trouble; next, clean cows with a history of udder trouble, and last, the cows that, at the time, have mastitis in any form.

By Ease of Milking. The easy-milking cows may be placed on one end and hard milkers on the other, with medium milkers in the middle. With this arrangement the easy milkers can be milked first with the more difficult ones left until last when more time is given to milking them out clean. Some dairymen, however, prefer to begin on the hard milkers and get them

milked first while the men are fresh on the job Either method gives satisfactory results if carried out properly

NAME PLATES

Good management of milking cows dictates that a name plate be placed over or in front of each stall, which should give the cow s name and her production In purebred herds this is an advantage when showing the cattle to visitors and prospective buyers The name cards should be covered with glossy isinglass, acetate paper, or some other transparent material to protect them and keep them clean

TRAINING ANIMALS TO LEAD

In most herds animals must be handled at various times To make this easier, it is desirable to break all calves to a halter and train them to lead Calves are not difficult to train when 6 to 8 months of age They are teachable and not large enough to be difficult to control A simple device for helping to halter break calves and teach them to lead can be made A wagon axle is set in the ground The wheel is placed on it and arms are fastened on the wheel The calves are tied at the end of the arms. Four to six calves can be handled at a time It is similar to a miniature bull exerciser The purpose is not to exercise the calves but to let them become familiar with a halter tied to a movable object. It does a part of the man work usually required The need for training calves is greater in registered herds than in grade herds When animals are shown or taken to sales they should be trained to lead well.

PAINT

Dairy barns that are used for producing milk for the fluid milk market are required to be either painted or whitewashed on the inside The appearance of the interior is enhanced and made lighter It is easier to do a better job in the barn when there is more light.

Paint will last much longer than whitewash, but is more expensive. When paint is used anywhere around the barn or elsewhere that cattle can get to it, a nonpoisonous paint must be used. Lead paint is poisonous. Many cattle have died of lead-paint poisoning. They can get it by licking or chewing on painted boards. An almost empty paint pail is often the villain. A zinc base paint can be used.

For a long period of time it has been customary to paint the walls of the barn gray, up to the base of the windows, and to paint the remainder of the walls and the ceiling white or a very light color. More recently, various colors are being advocated and used. Such colors as buff, light green, and light blue are proving satisfactory.

WHITEWASH

Whitewash is excellent to use in all dairy buildings. It is simple to make and easy to apply, is a mild antiseptic, and is perfectly safe. The following formula has been recommended by the United States Department of Agriculture.

"Take a half bushel of unslaked lime, slake it with boiling water, cover during the process to keep in steam. Strain the liquid through a fine sieve or strainer, and add to it a peck of salt previously dissolved in warm water, 3 pounds of ground rice boiled to a thin paste and stirred in while hot, ½ pound of Spanish whiting, and 1 pound of clean glue previously dissolved by soaking in cold water, and then hang over a slow fire in a small pot hung in a larger one filled with water. Add 5 gallons of hot water to the mixture; stir well; let it stand a few days covered from dirt. It should be applied hot, for which purpose it can be kept in a kettle or a portable furnace. Coloring matter may be added as desired. When a less durable whitewash will answer, the above may be modified by leaving out the whiting and glue and omitting the boiling. It need not be applied hot and may be applied with a spray pump."

BEDDING

Some sort of bedding is necessary to provide comfort for the animals, to keep them clean, and to absorb the liquid manure The amount of bedding required depends upon the kind of floor that is in the barn, and the method of keeping the cows fastened With a cork brick or wooden floor less bedding is needed than if other materials are used Less bedding is also needed if the cows are fastened in stanchions with stalls of proper length than if they are fastened with chains or left loose in a box stall

The common materials used for bedding are straws of various kinds, corn stover, shavings, and sawdust The best kind depends upon local conditions On most farms sufficient straw is available, so that the problem of the proper kind of bedding is easily solved In many cases corn stover can be shredded and used for bedding It makes very satisfactory bedding materials

If the bedding has to be purchased the relative prices of the various bedding materials will usually be the deciding factor Shavings have been used extensively in many dairies with good success They have the advantage that they are clean and give the stable an appearance of cleanliness, which no other material can do Shavings can be purchased in carload lots, in bales which are easily stored and handled In regard to cost, the West Virginia Station found that they were the cheapest and most satisfactory bedding that could be obtained Soft wood shavings have a very much greater water holding capacity than those containing some of the hard woods, and are greatly to be preferred

The absorptive properties of different bedding materials are given by Doane * in Table XLV

The fertilizing value of the straws and corn stover is much greater than of either shavings or sawdust. Some dairymen are finding that cut straw is more economical than long straw The absorptive power is not changed but less short straw is wasted by undue amounts being worked back into the gutter

The bedding cannot be used too sparingly if the cows' udders are to be protected and the cows kept clean In trials at the Vir

* *Md Exp Sta Bul* 104

TABLE XLV

Absorptive Properties of Bedding Material

Material	Water-Absorbing Power of Bedding	Pounds of Bedding Required to Absorb for 24 Hours
Cut stover	2.5	4.0
Cut wheat straw	2.0	5.0
Uncut wheat straw	2.0	5.0
Sawdust	0.8	12.5
Shavings	2.0	4.4

ginia Station, large cows in stanchions and tie stalls required 6 to 8 pounds of long straw or about 30 pounds of sawdust per day.

In loose housing approximately twice as much bedding is required as in a stall barn. This depends a great deal on the kind of bedding material and whether or not the cattle are fed and watered away from the bedded area.

MANURE DISPOSAL

All manure should be removed from the dairy barn twice a day. There are several methods of handling it. In small barns it may be removed with a wheelbarrow. In larger barns it may be handled with a litter carrier. The carrier may run on a track in the litter alley or preferably mounted on a small rubber tired hand truck. With these methods the manure can be loaded directly onto a spreader and spread at once on the field, or accumulated in a manure pit, where it will remain until later to be spread upon the land. This will require additional handling of the manure and is expensive. If a pit is used it should be not less than 50 feet from the barn for sanitary reasons. Where the cows face out, there is only one litter alley. The manure spreader may be driven through it and the manure loaded directly on to the spreader. This saves extra handling.

Several makes of mechanical gutter cleaners are on the market. These have proved quite satisfactory and take the drudgery out of one of the hardest and dirtiest jobs on the farm. By their use the manure is removed from the barn and loaded onto the spreader.

Whatever method is used, the manure, especially in warm weather, should not be allowed to collect in the pit or in a pile for any great length of time, since it is an excellent breeding place for flies The practice of dumping the manure in a pile where the rain will wash out much of the fertilizing constituents should never be allowed Properly preserved manure will return to the soil about 75 per cent of the fertilizing value of the feed, but manure exposed to the weather loses a large percentage of its value

The liquid part of the manure is rich in nitrogen and potassium Sufficient bedding should be used to absorb all the liquid in order to save its fertilizing value In the summer many dairymen place a small amount of bedding in the gutter each day just to absorb the urine In a limited number of cases the liquid is drained off into a tank From there it is pumped into a special liquid tank spreader and taken to the field With this method, only a limited amount of water should be used for washing down the barn and gutters Otherwise, the water will dilute the urine and increase the amount of liquid to handle.

FLIES

Flies are a great annoyance around the dairy barn and to the cows in the field Dairymen should, as far as possible, destroy the breeding places of flies They should keep the manure well cleaned out and all other breeding places cleaned up

Effect of Flies on Milk Production. The California Experiment Station * found that an exceedingly large number of flies reduced milk production from 1 4 per cent to 9 3 per cent. It was formerly believed that one of the main reasons for the decreased milk flow in the late summer was torment of the flies The explanation of this is that the appearance of flies in great numbers is coincident with the drying up of the pastures and the beginning of summer heat, so that dairymen attributed to the flies the additional loss in production which was caused by hot weather and insufficient feed

* *J Dairy Sci*, 19 11

Oil Sprays. The old-type oil sprays were found to be detrimental to milk production. They remained on the hide and hair to be effective over a longer period. In so doing they caused the hair to be matted with oil and dust. The spray thus had an adverse physiological effect upon the cow, increasing the body temperature and rate of respiration. The newer type oil sprays are volatile and do not have the same criticism as the old gummy types of sprays.

New-Type Insecticides. During World War II and since, a number of new chemical insecticides have been developed. DDT (Dichlorodiphenyltrichloroethane) was first used extensively. Generations of flies gradually built up a resistance to it and it was not so effective as when it was first used. Then, too, it was found that when used on milking cows and in dairy barns it could be carried over to some extent into the milk. When animals are fattened, DDT may be desposited in the fat. DDT is not now recommended for use on milking cows or in dairy barns. Toxaphene may be used to control flies on cattle, except milking cows.

Methoxychlor is the spray most generally recommended for fly control on dairy cattle, in dairy barns, and in milk houses. It is a residual spray. On cattle it can be expected to last from 3 to 5 weeks. In the barn it will be effective much longer. Three applications will take care of the barn all summer. With cattle, rains will ultimately remove the residue. Brushing the cows will manually remove some of it, and in dry weather dust may coat it over and reduce its effectiveness in killing. Lindane is another spray recommended for a residual spray in the barn, milk house, and on cattle, except for young calves.

These insecticides are slow killers. A fly will absorb enough of the chemical in a few seconds to kill it, but it may take several minutes or hours to make the kill. Pyrethrum sprays are fast killers and can be used to supplement the others. This is an oil-base spray and must be used with care if it is used on animals. All these insecticides are poisons. They should be used with reasonable precautions. Mangers and water cups should be covered when the barn is sprayed. Likewise, all feed should be

protected from the spray. No doubt new chemicals will be discovered and produced, which may be even more effective

Flies are annoying to man and cow, they are unsanitary They spread certain diseases They may contaminate milk. Every precaution should be taken to control them.

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17

Milking the Dairy Herd

Milking is one of the most important jobs on the dairy farm. It is important because the amount of milk that a cow will give will depend to a certain extent on how she is milked. A cow may be fed and treated as she should be, but unless she is milked properly she will not produce her maximum, and a loss in milk flow and in profits will result. Milking also requires more time than any other one job in the production of milk. Studies * † have shown that from 48 to 68 per cent of the time spent in caring for the milking herd and handling the milk is required for the milking operation.

Milking is not an easy task and is one of the least-liked jobs on the farm. This is true because on many farms the milking chore is something attached to each end of a day's work and is not a definite part of that day's work. Although the milking job may represent on many farms only a small part of a man's work, it should be a definite and regular part and should be performed at an allotted time. The milking hour should be respected and not encroached upon by other jobs. Under such circumstances, milking is not disliked, and may even be preferred to many other tasks. In large dairies, milking may be the main duty of a certain worker, but whether in small or large herds, the persons responsible for the milking should do it regularly, except when relieved by a relief milker.

A Good Milker. A good milker is one who likes cows and who is gentle with them. His hands should be soft and pliable. The operation of milking should be uniform, rapid, and continuous until all the milk has been drawn. After it is once started, the

* *Mich. Quart. Bul*, 30.15.

† *Md. Exp. Sta. Bul.* A46.

operation should not stop until the cow is completely milked

In milking, the hands should be dry, the practice of wetting them before or during milking is unsanitary The method of milking should imitate that of the calf as closely as possible The operation consists of an upward movement followed by a downward pull accompanied by pressure The whole hand should be used, not merely one or two fingers Unless the teats are small, the squeezing should be accomplished by closing the whole hand, first at the top of the teat, to check the backflow of milk, and then on the rest of the teat

A good machine milker must know the operation details of his machine and be able to keep it in the best operating condition He should be able to recognize abnormal conditions of the teats and udder by sight and feel He should be able to move about the cow gently and quietly to avoid making her nervous and afraid. A good milker is a skilled workman—rapid efficient, gentle, and clean Such milkers will get more and cleaner milk from a cow than will a slow, inefficient, and careless milker

MANAGED MILKING

Research work has resulted in great improvement in the milking operation, particularly in the use of the milking machine Managed milking is fast milking, although milking a large number of cows in a short time is not necessarily managed, or efficient, or even complete milking The term managed milking" is much more descriptive than is fast milking or 3-minute milking It does not mean that the milker must work faster, but it does mean that cows can be milked in less time and with less hard work

A managed milking program is made up of several coordinated steps that are given in detail in the following discussion

Preparation for Milking In preparing for milking, the milking barn or milking parlor should be clean and free of dust and odors The equipment should all be assembled, the milker should be ready to give the milking job his undivided attention and the cow should be prepared for a quick "let down" of her milk

Assembling the Cows Previous to milking time, the cows should be brought into the barn and groomed This will give

time for the cows to get settled and quiet, and for the milker to have them cleaned before milking begins

FEEDING It is a common practice to feed the cows their grain some time before milking so that they will have it completely eaten when milking starts However, the time of feeding varies with individual dairymen Some feed their cows when the milk

FIG 25 Udder before let down of milk (*W Va Univ*)

ing starts and a few wait until they are through milking before feeding The cow is a creature of habit and will adjust herself to any of the above feeding routines if it follows every milking Feeding before milking is the most convenient from a management standpoint and is generally practiced If a cow is trained to be milked while eating she expects to get her feed then and will not milk completely if she is not given her grain The feed in this case is a part of the let down stimulus Those who train their cows to be milked first and fed later do not want their cows to be interested in getting their feed and stretching around for it while they are being milked

EQUIPMENT The equipment used in the milk room and milking barn should be prepared and assembled before milking time A milk equipment cart is convenient for handling the milking equipment in the barn and moving it from the milk room to the barn and returning it when milking is completed

OPERATOR. The milker should have his work organized so that he does not have other jobs to look after during the milking period Such jobs as brushing the cows, breeding, feeding calves etc, should be done before or after the milking period

NUMBER OF MILKING-MACHINE UNITS The number of milker units that a milker should operate depends to some extent upon the individual One should use the number that he can operate most efficiently If a person is rather slow and carries his own milk to the milk room, one unit is probably all that he can handle efficiently A milker who works fast can handle two units with a helper carrying and weighing the milk. It is the unusual milker who can handle more than two units and operate them efficiently

PREPARATION OF THE COW Preparing the cow for milking is important for producing clean milk, for getting it in the shortest period of time and for getting all of it

The "let down" hormone, oxytocin, was discussed in Chapter 5 The hormone is produced as a result of a stimulus This stimulus may be the sight of the cow's calf, its warm, wet mouth on the teats, the rattle of milk pails, the click of the milking machine, the act of being fed, the manipulation of the teats and lower part of the udder, the washing of the teats and udder, or other incidents that the cow associates with being milked

The calf sucking is nature's method of stimulation The one most nearly like nature's method is the washing of the cow's teats and udder with warm water Normally, the reaction to the stimulus is effective in 45 seconds and it remains effective for only about 7 minutes The milking should be completed within this time The udders of only one or two cows should be washed at a time The practice of washing all the cows' udders before starting to milk is not to be recommended

As soon as the udder is washed, a few streams of milk should be drawn by hand from each teat into a strip cup covered with a fine meshed screen This milking opens up the teat canals so that there will be no delay in the milk starting The use of the

strip cup makes possible the examination of the milk from each quarter before the teat cups are attached

An individual towel or cloth for washing the udder is preferable as this gives a clean towel for every cow and eliminates the possibility of transmitting any udder infection from cow to cow Special paper towels are available for washing the udders They

FIG 26 Washing the udder and teats with warm water (*W Va Univ*)

are stronger than the average paper towel Results * indicate that the response to washing with a paper towel is no different than when a cloth towel is used Paper towels are disposable into the gutter and through the manure, as they soon disintegrate

Excitement or unusual conditions in the barn at milking time interferes with the 'let down' response Rough treatment, loud noises, strangers, barking dogs, failure to get feed at the regular time, and many other conditions react adversely on the amount of milk that can be secured When a cow becomes frightened or annoyed, a second hormone, adrenalin, is produced Adren-

* *J Dairy Sci*, 34 6

alin causes the blood vessels to contract and in some manner counteracts the effects of oxytocin All cows are not the same in their response to disturbances, and a cow can get used to or adjust herself to some disturbances, such as strangers in the barn at milking time

It must also be considered that radio programs strangers, or other irregular conditions may effect the efficiency with which the milker does his part of the job

Milking About 1 minute after washing the udder, and not later than 2 minutes, the teat cups should be attached Most cows will milk out in 3 to 4 minutes, some in less time However, some cows are slow milkers, either because they have obstructions in the teats or udder that hinder the flow of milk or simply because they are in the habit of slow milking Usually, these latter can be trained to milk more quickly, but they should be milked completely even though more time is required First calf heifers and young cows are more easily trained to the program than older cows that have developed slower milking habits

The milker can develop the technique of knowing by sight but more particularly by the feel of the udder when it is time to remove the machine He soon learns the time required to milk each cow and should be ready to remove the milker as soon as milking is complete

Stripping The machine may not get the last milk from the udder This must be secured either by hand stripping or by machine stripping An easier and better job can be done by machine stripping With the weight of the udder decreased and probably some milk ducts that do not normally empty there is always some milk trapped in the udder The operator can pull down on the teat cups with one hand and massage the quarters with the other, progressing around the udder, and do thorough stripping with the machine Of course, with any method of stripping the last drop is not secured

The teat cups should be removed as soon as the udder is empty and not be allowed to creep up, for it is then that the milker may damage the udder

Cows Like to Be Milked. Observation shows that cows like to be milked Under normal conditions their reactions are shown by their general willingness to be milked by hand or with a

Fig 27 Foremilking into a strip cup (*W Va Univ*)

Fig 28 Udder after let down of milk (*W Va Univ*)

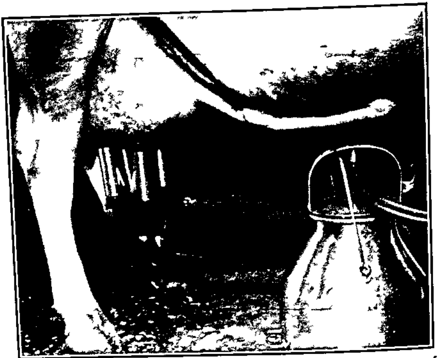

FIG 29 The milking machine should be attached in 1 or 2 minutes after washing the udder (*W Va Univ*)

FIG 30 Stripping by machine pull teat cups down with one hand and massage udder with other hand (*W Va Univ*)

machine. This is especially true when the things that they associate with milking are pleasant.

When there are conditions associated with milking that they dislike or are painful to them, they often respond by failing to cooperate with the milker when he attaches the teat cups and do not stand quietly while being milked. A sore teat on a tender quarter will cause the milking process to be painful to the cow. If the cow associates being milked with being roughly treated she will resent being milked.

Rules for Good Milking. The rules for good milking are summarized as follows. (1) Avoid excitement of the cows previous to milking and during the milking period. (2) Prepare and assemble all milking equipment before the milking begins. (3) Do not allow the milking period to be interrupted. (4) Milk at the same time every day, with the milking periods as evenly divided as practical. (5) Prepare the cow for the "letdown" of milk by cleaning the udder and teats with a damp cloth or paper towel and using a strip cup. (6) Begin milking within 1 or 2 minutes after preparing the cow. This applies to both hand and machine milking. (7) Remove the teat cups as soon as the milk stops flowing. (8) Strip the cow clean, either while the machine is attached or by hand stripping.

Routine for Managed Milking. A definite schedule needs to be followed to apply these eight rules of managed milking. The milker should adopt a schedule of milking that is best adapted to him and his conditions, then follow the schedule conscientiously. The following schedule may be observed by a milker when operating two units. (1) Prepare first cow. (2) Prepare second cow. (3) Place machine on first cow. (4) Place machine on second cow. (5) Prepare third cow. (6) Strip first cow and remove machine. (7) Change pails or empty milk. (8) Dip teat cups in a pail of water, then in a pail of disinfecting solution (chlorine or quaternary solution). (9) Place machine on third cow. (10) Prepare fourth cow. (11) Strip second cow and remove machine. (12) Continue this schedule for the entire herd.

THE MILKING MACHINE

A number of milking machines on the market are efficient when instructions for their operation and care are carried out in detail

Vacuum All machines operate on a vacuum or negative pressure The correct amount of vacuum varies with different machines Usually the amount of vacuum recommended is within the range of 10 to 15 inches The amount of vacuum or suction reaching the teat is lower than that in the pipeline or pail An easy milking cow will have less suction on the teat than a hard milking cow because the heavier flow of milk reduces the amount of vacuum

When the milk stops flowing a higher vacuum reaches the teat and may damage the teat lining Excessive vacuum may injure the teat and udder Too low a vacuum below that recommended for the specific machine reduces the rate of milking

Pulsations The rate of pulsation is constant with some machines and cannot be changed except by running the pump at a higher rate of speed In other machines the rate of pulsation is adjustable These sometimes vary either by the adjustment becoming loose or with the variation in temperature

The usual pulsation rate is 48 to 52 pulsations per minute The rate of milking is not increased by stepping up the number of pulsations per minute The complete suction is on during only half of the cycle The pulsation gives an alternate suction and release therefore increasing the rate of pulsation does not increase the time that milk flows from the udder Slow pulsations below 40 per minute cause congestion in the teats and produce a less efficient job of milking

Care of Milking Machine The machine should be checked and cared for in the same manner as any other delicate machine All parts including the pipelines and stall cocks should be kept clean and operating normally The teat cup liners and other rubber parts especially should be kept in good condition and properly stretched and any defective ones should be replaced Refer to Chapter 32 for information on sanitary maintenance of the milker parts

HOW MACHINES MAY DAMAGE THE UDDER

A properly operated machine will not injure the udder. A machine that is not operated as it should be may injure the lining of the teats and udder and create a predisposing condition for bacteria to become established. It may also cause mastitis.

Teat Cups Kept on Too Long. The greatest cause of machine injury is leaving the teat cups on too long. When milk is flowing from the udder there is no vacuum exerted within the teat or udder. The milk leaves the udder because the pressure within the udder is greater than the pressure in the teat cup. As soon as milk ceases to flow, a suction is established within the teat canal and udder. When there is no milk to act as a cushion to hold the tender linings apart, the suction draws them together and the rasping action may irritate the delicate membrane lining the teat and udder.

When the udder is nearly milked out, the teat cups will crawl up on the teats and may even draw the lower part of the udder into the teat cup. This shuts off the flow of any milk that may be left. The operator should be ready before this happens to attend to the machine and keep the teat cups pulled down to complete the milking and do the stripping.

Too Much Vacuum. When the machine is operated with excessive vacuum the udder tissue is subject to injury by its action on the tender lining of the teat cistern.

Incomplete Milking of Quarter. When one quarter is more difficult to milk than the others it may be milked incompletely if the machine itself is depended upon. Milk left in the quarter predisposes it to mastitis, and may cause the quarter to give progressively less milk and become smaller than the other quarters. A study * on incomplete milking indicated that cows which were not stripped out completely produced 96 7 per cent as much milk as those that were stripped. In these studies it was estimated that an average of 0 3 pounds of milk was left in each quarter.

Teat Erosion. If the teat cups are allowed to remain on too long over a long period of time, the ends of the teats may become

* *U S D A. Tech Bul* 522.

eroded and hard An area around the teat opening is affected This may cause the sphincter muscle more difficulty in closing the teat canal which may allow the entrance of many bacteria into the teat cistern

PRODUCTION OF DIFFERENT QUARTERS

Milk production is not the same from each quarter The rear quarters usually are larger than the forequarters and on the average produce from 58 to 60 per cent of the total milk

The rear quarters normally are slightly lower than the forequarters A suspended type of machine is made to pull slightly forward and the claw type milker may also be set forward in the stall to pull forward This gives more pull on the rear quarters and tends to milk all quarters out in about the same length of time

IRREGULAR FEEDING AND MILKING

The cow is a creature of habit and expects the same routine every day Cows that are fed and milked irregularly * produce about 5 per cent less milk than the same cows fed and milked regularly The irregularity of feeding appears to have a greater effect than irregular milking Probably the appetite is more sensitive to a routine than is pressure within the udder

Even milking periods are desired that is if cows are milked 2 times per day the milkings should be approximately 12 hours apart and if milked 3 times a day the milkings should be at approximately 8-hour intervals

Cows that are milked 3 times a day will produce more milk than if they are milked twice a day Heavy producers show the greatest differences Milk secretion within the cells of the udder is a continuous process and therefore it tends to build up a back pressure As this pressure within the udder increases the secretion of milk is slowed down and if the pressure should reach 30 to 40 millimeters pressure † secretion ceases altogether until after the cow has been milked

* *U S D A Circ* 180

† *Proc Soc Exptl Biol Med* 30 254

Consequently, long intervals between milkings cause a high-producing cow to produce less milk than if she were milked at shorter intervals.

Many dairymen do not milk at even periods because it makes the day too long. This management factor can be partly overcome by allowing the milkers time off during the day. Periods between milkings should not be more than 11 and 13 hours for twice-a-day milking.

Change of Milkers. It is preferable that the same milker milk the same cows regularly. This is not so essential with machine milking as with hand milking; however, different milkers handle the preparation of the cow and the machine differently. The most important factor is that each milker be competent. It has become a practice in the majority of commercial dairies for the workers to be off 1 day each week. This necessitates a change in milkers at such times.

PREPARTUM MILKING

Cows that have previous mastitis history and those that have large and swollen udders are often milked 10 days or 2 weeks before they are due to freshen. Some breeders milk their first calf heifers prepartum, believing that it will ease the pressure on the udder since they have not as yet developed strong ligaments to support the udder, and also believing that the heifer will become more easily broken to milk before freshening.

Experience has shown that prepartum milking may be of benefit to cows that are subject to mastitis. If the milk is cleaned out of the udder before freshening, the udder may be cleared of infection and the cow will develop into a valuable milker. There are no results of controlled experiments to prove that prepartum milking will lessen the congestion and swelling on the udder and belly of the cow. Some cows do not give any milk before freshening; others produce a moderate amount; and a few will produce large amounts. However, cows giving large amounts do not seem to reach the peak of production any earlier than do those milked normally. There appears to be enough of the colostral qualities to the milk, even of those cows whose milk appears

normal at time of calving, to keep the calves in good growing condition, especially if the calves are given a little cod liver oil

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18

Raising the Dairy Calf

Approximately 25 million dairy cows are in the United States. The average age at which the cow is removed from the herd is about 7 years. On the assumption that a cow gives birth to her first calf at 2½ years of age and to one calf every 12 months thereafter, the average cow would give birth to five calves in her lifetime. Her period of usefulness in the herd, therefore, is less than 5 years. On this basis, from 5 to 6 million calves must be raised every year to maintain the present number of dairy cows. Furthermore, it is necessary to raise an additional number to keep pace with the demand brought about by the increase in the human population. Since many calves die during the first months of life and many are disposed of later, it is necessary for the dairyman to retain about three calves for each two cows that are to be replaced. When rigid culling for low production is made, an even greater number must be kept. Therefore, the number of dairy calves actually being raised in this country at any one time is quite large.

IMPORTANCE OF RAISING DAIRY CALVES

It is a well-known fact that the dairy cow inherits her milk-producing ability, and that it is impossible by any kind of feeding to make an animal produce milk in excess of her inheritance. Since this is true, it is essential that the dairy farmer raise only the heifer calves from cows possessing high milk-producing qualities. This is the way in which he can hope to maintain the level of production of his herd. By careful mating and feeding he may develop a herd of cows with a higher average production than that with which he started.

Near the larger cities where the price of milk is high, many of the dairymen, instead of raising calves, depend upon purchasing cows with which to make replacements From the standpoint of immediate monetary return this method may be the best, but it has several disadvantages that make it undesirable In the first place, only too often the cows that can be purchased are culls, and if the best cows in a herd are purchased the price paid is usually high Furthermore, the buyer always runs the risk of bringing diseases, such as mastitis and Brucellosis, into his herd It is a well established fact that little or no improvements results when this method of maintaining the herd is followed Herd improvement can come only when discarded cows are replaced by well raised heifers of good breeding and type The surest and most practical way in which the dairyman can secure these is to raise his own heifer calves from the best cows in the herd and have them sired by a good purebred bull There are successful specialized dairies in which no young stock is raised, but such herds show no continued improvement from year to year

CARE OF THE COW AND CALF AT CALVING TIME

If the cow is confined in the barn she should be put into a well bedded box stall a few days previous to the time of calving. Although it is not always necessary for the attendant to be present when the cow is calving he should be near by so that he can give assistance if necessary, but he should disturb her as little as possible If the cow calves normally she will immediately begin to lick the newborn calf, and will thus stimulate respiration, improve the circulation and dry the young animal Sometimes the fetal membrane covers the nostrils, and the young calf may suffocate unless this is promptly removed Occasionally, a cow, even though she may have had several calves will refuse to own her calf In such cases it is necessary to remove the calf to a safe distance and to dry it with burlap or other dry cloths Generally, after a brief absence the calf may be returned and the mother induced to adopt it

A vigorous calf will attempt to rise in about 15 minutes and usually will be nursing in half an hour The weaker the calf,

the longer the time before it will be able to be up and nursing. Some calves are unable to nurse by their own efforts; it is then necessary to assist the calf by holding it up to the cow's udder. If the calf is so weak that it is unable to drink, even when held up, it may be necessary to feed it with a nipple, either from a bottle or pail. It is always desirable to treat the navel with tincture of iodine or another disinfectant. This may prevent disease germs from entering by this avenue.

CARE OF THE NEWBORN CALF

The first milk that a cow gives after dropping a calf is called colostrum. It is viscous and yellow in color, containing much more protein, ash, carotene, and vitamin A than normal milk. It is laxative in nature and contains antibodies which tend to enable the calf to ward off diseases until its body has had time to establish its own immunity. The milk from a fresh cow is usually considered suitable for human consumption about the eighth milking after the cow's freshening.

One of the special purposes of colostrum seems to be to cleanse away the metabolic products that have collected in the intestines of the young animal during the latter portion of its fetal days. Ordinarily, the colostrum should be fed for the first 3 or 4 days or until the milk becomes normal. When prepartum milking is practiced, no typical colostrum may be available. Some dairymen make a practice of freezing the colostrum that is secured by milking before the calf is born and feeding it after the birth of the calf. Usually, however, the milk will contain sufficient colostral qualities that the calf will grow normally on it if given some vitamin A supplement.

If no colostrum is available because of the death of the dam or other reasons, the calf may be fed the normal herd milk, but this should be supplemented daily with 20 milliliters of codliver oil or with some other source of vitamin A. Two ounces of castor oil may be given to compensate for the laxative effect of the colostrum.

Feeding Colostrum to Other Calves. When all the colostrum is not needed for the newborn calf it may be fed to the older calves and thus save marketable milk. It contains from 1½

to 2 times as much total solids as does normal milk and when fed without dilution may cause scours When fed to older calves the amount fed should be reduced or it should be diluted, by mixing it with warm water or with the regular milk This dilution should not be more than two parts of colostrum to one part of the warm water or milk but may be much less than this, depending upon the supply

TABLE XLVI

BIRTH WEIGHT OF CALVES OF THE DIFFERENT BREEDS *

Breed	Average Weight Males pounds	Average Weight Females, pounds	Mature Weight Males pounds	Mature Weight Females pounds	Weight of Calf in Proportion to Mature Weight of Females per cent
Jersey	60	53	1500	970	5 46
Holstein	95	90	2200	1370	6 57
Guernsey	71	65	1760	1070	6 08
Ayrshire	80	72	1850	1100	6 55
Brown Swiss †	85	80	2000	1300	6 15

* *Mo Exp Sta Bul* 336

† Mature weights of males and all data on Brown Swiss are estimated

Birth Weight. Table XLVI, compiled at the Missouri Experiment Station, shows the average birth weight of calves of different breeds

Male calves are usually a little larger than females In this study the males averaged 5 to 8 pounds more than the females Also the first calf of a heifer was somewhat smaller than the average of the breed On the average, the maximum weight of calves at birth was produced by cows between their third and sixth calvings Old cows seem to have a tendency to drop smaller calves than they did in their prime

The nutrition of the cow during gestation does not greatly influence the size of the resulting calf Cows fed continuously over long periods of time on very low grade hay produce weak and often dead calves largely because of low carotene intake Cows fed feeds rich in carotene for 30 days prior to calving will

produce calves with a higher vitamin A storage than they will when on a poor roughage ration lacking in carotene.

It has sometimes been observed that a cow in very poor flesh may drop a calf of normal size, and that a cow in very good flesh may drop a calf that is small for the breed. The condition of the cow does not seem to affect the size of the calf. This can be explained by the fact that the composition of the blood from which the fetus receives its nourishment tends to remain constant even though the feed supply is limited. A shortage of most constituents in the blood is made up by drawing upon the reserve supply in the body. For this reason, the food supply of the fetus remains practically constant even under adverse conditions.

Removing the Calf from Its Dam. There is a great variation in practice regarding the best time to remove the calf from the dam. Some successful calf raisers take the calf away from its dam at once, without allowing it to nurse at all. Others allow it to nurse once, and still others allow it to remain with its dam for 3 or 4 days, or until the congestion is out of the udder and the milk is suitable to put in the regular supply. It probably makes little difference as to when the calf is removed from its dam. The arguments for removing the calf from the cow early are that a calf may be taught to drink from the pail more easily; the amount of colostrum that the calf receives can be better controlled; and less fretting on the part of both the cow and the calf occurs. However, when the calf is allowed to remain for 2 or 3 days there is usually not much trouble in teaching it to drink, especially if a nipple pail is used. While the calf is with the cow it will usually consume the colostrum in small quantities at frequent intervals, in a manner most adapted to its digestive system. The usual practice is to remove the calf from its dam on the third day.

Teaching the Calf to Drink Milk. The longer a calf nurses its dam the more difficult it is to teach it to drink milk from an ordinary pail. By instinct, a calf stretches upward to receive its nourishment. In learning to drink from an ordinary pail, however, it must be taught to bend downward. There is no better method of teaching the calf to drink from an open pail than the

simple one of putting one's fingers in its mouth, bringing head and fingers into a pail containing a small amount of whole milk, and then carefully withdrawing the fingers It will probably be necessary to crowd the calf into a corner, and to stand astride of its neck in order to teach it in this way Some calves learn to drink with the first attempt, with others it is quite a long process Some dairymen omit the first feeding after taking the calf from the cow, thinking that the calf will be more eager for its feed and will be easier to be taught to drink from the pail Such a method may not be detrimental to a strong calf but with weak calves it will further weaken them and should not be practiced

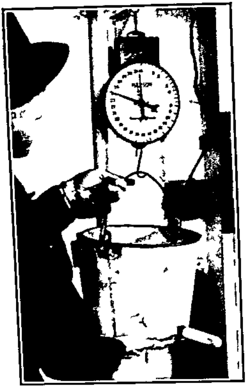

FIG 31 A nipple pail for feeding calves (*W Va Univ*)

THE NIPPLE PAIL. The nipple pail has come into favor with many calf raisers It has the advantage that the calf is taught to drink its milk more easily through a nipple than from an open pail Drinking the milk more slowly will cause the milk to go directly to the abomasum rather than to the rumen Milk going into the rumen before the calf is ruminating is likely to cause digestive upsets

THE AMOUNT OF WHOLE MILK TO FEED The calf should be fed the milk from its own dam for a few days, after which it may be fed milk from the herd Many dairymen feed the calves milk from the lower testing cows in the herd

The amount of milk to feed young calves depends upon the size of the calf A general rule is to feed about 1 pound of

milk for each 10 pounds of body weight. A Jersey calf weighing about 60 pounds should be fed about 6 pounds of milk per day and a Holstein calf weighing 90 pounds should be fed about 9 pounds per day. These amounts should be increased as the calf grows but need never go above 12 pounds per day. The milk should be fed in equal portions twice per day. In many of the newer methods of feeding calves, the amount of whole milk is kept at the minimum.

TEMPERATURE. The young calf should be given its milk at the temperature of milk fresh from the cow, which is from 90 to 100°F. For the first few weeks the calf is especially sensitive to changes in the temperature of its milk.

SANITATION. Under any system of feeding it is essential that strict sanitation be practiced. All the utensils used for feeding calves should be washed and sterilized after each feeding, in the same thorough manner as the dairy utensils. Nipple pails require more attention, since they are more difficult to keep clean. Seamless metal pails are recommended. If the pails have seams, they should be filled flush with solder so that milk will not lodge, furnishing food for bacteria. Many of the disorders of the digestive system of the calf can be traced to unclean utensils. The pails, or feed boxes in which grain is fed, must also be kept clean.

METHODS OF RAISING CALVES

The milk-feeding period is the most expensive period in the raising of the calf; it is likewise the most critical period in the life of the calf. The young calf's digestive system is virtually a single-stomach system up until the time the calf begins to consume roughage in quantity and starts to ruminate.

The methods of raising calves are: (1) the nurse-cow method, (2) the whole-milk method; (3) the skim-milk method; (4) the calf-starter method; and (5) the milk-replacement method.

The Nurse-Cow Method. The use of a nurse cow in raising calves is nature's method. In practice, it is usually more expensive than most other methods. It is the usual way of raising veal calves. Some purebred breeders use it for raising their more valuable calves, whereas others use it for all their calves,

but at its best it is usually an expensive method Sometimes, certain old foundation cows or cows with three quarters may be used successfully as nurse cows With their use, less difficulty is usually experienced with digestive disturbances in the calf From 2 to 4 calves of about the same age and vigor can be nursed by one cow It is often difficult to have the right number of calves available to keep on the nurse cow If there are too many, some will not receive sufficient milk, and if too few, some will receive more than they need and thus lead to waste A cow can nurse several sets of calves during her lactation

The Whole Milk Method. Calves will make their greatest growth and will show the greatest amount of bloom when they are on a nurse cow or when they are fed liberally on whole milk. The whole milk method of feeding calves gives less trouble from digestive disturbances than other methods of hand feeding. It is an expensive method A calf that is fed whole milk for 3 or 4 months will consume 1000 pounds or more of milk.

In using this method, a mixture of farm grains should be placed before the calf when it is a week to 10 days of age Green leafy hay should also be placed before it at about the same time and the calf should be encouraged to eat both hay and grain as soon as possible Grain and hay may be fed as outlined under skim milk feeding

The Skim Milk Method. On farms where cream is sold or butter is made, fresh skim milk is available for feeding calves Skim milk may be reconstituted by dissolving skim milk powder in warm water One pound of the powder dissolved in 9 pounds of water will result in a product of approximately the same composition as regular skim milk. Some feeders like to increase the solids in the skim milk by dissolving 1 pound of the powder in 6.5 pounds of warm water This makes a product containing approximately 13 per cent of solids and less of it need be fed

Table XLVII shows the average composition of whole milk, colostrum skim milk, buttermilk, and whey

As will be noted the only apparent difference between skim milk and whole milk is that the fat has been removed from the former but with it the fat soluble vitamins A and D are also removed Substitutions can be made for the fat and vitamins

TABLE XLVII

AVERAGE COMPOSITION OF WHOLE MILK, COLOSTRUM MILK, SKIM MILK, BUTTERMILK, AND WHEY *

	Water, per cent	Ash, per cent	Fat, per cent	Protein, per cent	Sugar or Carbohydrates, per cent
Whole milk	87	0 7	4	3 3	5
Colostrum milk	74 5	1 6	3 6	17 6	2 7
Skim milk	90 5	0 7	0 3	3 4	5 1
Buttermilk	91	0 8	0 5	3 5	4 2
Whey	93 4	0 7	0 3	0 8	4 8

* *Mo Res Bul* 35

and practically as good calves can be raised on skim milk as those raised on whole milk or those allowed to run with the dam The calves may not be so fat and thrifty looking, but they will grow into just as large and productive cows

CHANGING TO SKIM MILK Calves that are to be raised on skim milk should be fed on whole milk for the first 10 days or 2 weeks, and, if the calf is not thrifty, even longer The change should not be made until the calf is growing vigorously The transition period from whole to skim milk should require about a week For the first day or two, about a pound of skim milk should be substituted for an equal amount of the whole milk, and later the amount should be gradually increased If whole milk is extremely valuable and the calves quite thrifty, the change can be made in 4 or 5 days if attention is given to details After the change has been made, the amount of skim milk should be gradually increased as the calf increases in size, until 12 pounds daily is being fed

TEMPERATURE AND QUALITY OF SKIM MILK The skim milk should be fed to the calf at about the temperature of milk fresh from the cow It is always best to feed the skim milk when it is fresh There is no easier way to upset the digestive system than to feed sweet milk at one feeding and sour milk at the next Sour milk can be fed successfully to calves if care is taken to see that it is always uniform in quality

If the skim milk is obtained at the creamery, it is necessary that it be pasteurized before being fed to calves Otherwise,

the milk may carry disease germs that might infect the herd Many states have laws requiring such milk to be pasteurized

The skim milk may be fed for 3 or 4 months, and, if the supply is ample, for longer period

CONCENTRATES WITH SKIM MILK Since the fat has been removed from the skim milk, it is necessary that some grain, or grain and hay, be fed as soon as the change is made Calves should be taught to eat grain as soon as they have been weaned from whole milk or earlier if possible, to take the place of the nutrients removed when the milk is skimmed

Many grain mixtures have been proposed for dairy calves although the kind of grain fed when on skim milk is not too important It has been found that almost any combination of grains may be fed successfully The principal necessity is to replace the energy and vitamins which have been removed in the fat The ration need not contain a high protein feed since the protein of the milk has not been removed Good quality hay will supply the vitamins

In the sections where corn is plentiful it may be used as the basis of the ration It is desirable, however, when nonlegume hay is used for the roughage, to have some high protein feed in the grain ration The following grain mixtures have been used with good results

Mixture 1

3 parts cracked or whole corn
3 parts crimped or whole oats
3 parts wheat bran
1 part linseed or soybean oil meal

Mixture 2

2 parts crimped or whole oats
2 parts wheat bran
1 part linseed or soybean-oil meal

Mixture 3

3 parts cracked or whole corn
1 part wheat bran

Calves like cracked or crimped grains better than ground grains They can eat and digest whole grains satisfactorily

(For Jerseys Guernseys, or Ayrshires)

Age of Calf	Whole Milk pounds	Skim Milk, pounds	Grain pounds	Hay, pounds
1 to 3 days	With dam			
3 to 14 days	6 to 9			
2 to 3 weeks	9 to 1	1 to 9	1/8	
3 to 4 weeks		10	1/4	
4 to 5 weeks		11	1/2	
5 to 6 weeks		12	3/4	All will ea
6 to 8 weeks		12	1	
8 to 12 weeks		12	2	
12 to 18 weeks		12	3	

(For Holstein or Brown Swiss)

Age of Calf	Whole Milk pounds	Skim Milk, pounds	Grain pounds	Hay, pounds
1 to 3 days	With dam			
3 to 14 days	9 to 11			
2 to 3 weeks	11 to 1	1 to 11	1/8	
3 to 4 weeks		12	1/4	
4 to 5 weeks		12	1/2	
5 to 6 weeks		12	3/4	All will e
6 to 8 weeks		12	1	
8 to 12 weeks		12	2	
12 to 18 weeks		12	3	

Whey and Buttermilk for Calves The analysis of butterm as shown in Table XLVII, is very similar to that of skim m and so the same supplements that are used with skim milk c be successfully used in raising buttermilk calves On m farms however, where buttermilk can be secured, skim milk also available and as a rule it will be found that sweet sk milk grows a better and thriftier calf than buttermilk So experiments, however show that calves fed buttermilk are l subject to scours than those fed skim milk Buttermilk fr neutralized cream is not satisfactory

Whey has a higher percentage of water and a much lo amount of protein but about the same amount of fat and su as skim milk. If whey is to be fed the grain mixture m have a high protein content Linseed meal is often mixed a gruel in the whey If whey must be fed it should not be until the calf is 5 or 6 weeks old and even then great care m

be taken to prevent digestive trouble. After that age good calves can be raised on whey if it is properly supplemented and the calves are given good care. Dried whey may be used by mixing 1 pound with 9 pounds of water.

FIG. 32. A removable grain box and hay manger for calves (*V.P I.*).

The Calf-Starter Method. Where there is a good market for whole milk, usually no skim milk is available, and the use of whole milk as a feed for raising calves is too expensive. For these conditions a method of raising calves has been developed, in which the calves are given a start on a limited amount of whole milk and then changed to some kind of grain and hay

at an early age As little as 250 to 350 pounds of whole milk fed over a period of 4 to 5 weeks is required by this method The calves are started on supplementary feed as soon as they will eat it, which is usually when they are a week to 10 days of age

These supplementary feeds are usually called "calf starters" and contain feeds low in fiber, high in good quality protein and minerals and usually include supplementary vitamins A and D They may be in the form of meal, crumbles, pellets, or a combination of these They are fed dry The calves should be fed a liberal amount of good quality, green, leafy hay, which is also an excellent source of carotene, the precursor of vitamin A.

The length of time the calf is fed milk depends upon the vigor of the calf If it is strong and vigorous it will be consuming sufficient of the starter and hay to discontinue the milk when it is about 4 weeks of age If, however, the calf is small and weak the milk should be continued for 5 weeks or longer Usually, however when the calf is consuming about 3 pounds of the starter and a liberal amount of hay per day, it can be weaned from the milk As the calf increases in size it will need to consume 4 to 5 pounds per day along with the hay in order to make normal growth.

There are many good commercial calf starters on the market that will grow the calf satisfactorily Some of the earlier ones were not too successful since little was known about the importance of vitamins and minerals but at the present these deficiencies are being provided for in most of the commercial starters

Although it is possible for a dairyman to mix his own calf starter, it is often not practical because of the difficulty of securing quality ingredients in small quantities The Minnesota Station * was one of the first to try this system and the grain fed for the first few weeks was either cracked corn or crushed oats or a mixture of the two Later, a mixture of 4 parts corn meal, 1 part wheat bran and 1 part linseed oil meal was used along with a legume hay of good quality

The results were much better, however, when a calf starter with some animal protein was used, and milk was entirely re

* *Minn Special Bul* 91

placed after the first 4 or 5 weeks. As little as 150 to 300 pounds of whole milk per calf was required. One of the starters was formulated by the New Jersey Experiment Station.* At the beginning of the second week of the calf's life, the feeding of the starter and alfalfa hay along with the whole milk is recommended. At the beginning of the fourth week the milk is diluted with water, so that by the time the calf is 30 days of age it is receiving only water, dry mix, and hay. The ration is as follows.

100 pounds yellow corn meal
150 pounds ground oats
50 pounds wheat bran
50 pounds linseed-oil meal
50 pounds soluble blood meal
4 pounds steamed bone meal
4 pounds finely pulverized limestone
4 pounds salt

Another more complicated mixture that has been used extensively has the following formula.

200 pounds wheat bran
530 pounds yellow corn meal
400 pounds crimped oats
150 pounds corn distiller's grains with solubles
100 pounds alfalfa meal
150 pounds soybean-oil meal
100 pounds linseed-oil meal
100 pounds fish meal
100 pounds dried whey
100 pounds cane molasses
40 pounds riboflavin supplement
10 pounds ground limestone
10 pounds low-fluorine rock phosphate
10 pounds iodized salt
¼ pound D-activated plant sterol

There are many satisfactory calf starters that can be mixed or purchased. These should be fed until the calf is 3 or 4 months of age. At that time the calf can be gradually changed to one

* *N. J. Ext. Bul.* 73.

of the less expensive grain mixtures such as were suggested previously

The Milk Replacement Method. In an effort to reduce the amount of whole milk used in starting the calf to even less than that used in the calf starter method, a milk replacement method has been developed that entirely replaces the milk from the calf's ration after they are 10 days to 2 weeks of age Such replacements are being successfully used and calves are raised successfully by the use of only 70 to 100 pounds of whole milk, including the colostrum, and some with as little as 50 pounds A milk replacement differs from a calf starter It contains only feeds of high nutritive value and with a low fiber content. The ingredients are highly digestible The protein and vitamin content of the milk replacements are greater than of the calf starters

Greater care must be taken in raising calves by milk replacement than when feeding them with the use of more milk However, where calves are strong and vigorous and are maintained free from disease, good growth can be secured with the use of many of the commercial milk replacements The feeding directions should be closely followed and good management practiced if satisfactory results are to be obtained Most of the commercial milk replacements are mixed with warm water and fed as a liquid A few are prepared in pellet form and fed dry

The calves, when fed on such feeds, will not show as much bloom as those grown on whole milk but often do make equal gains in weight After 8 weeks of age, when they are removed from the milk replacement and fed a good grain ration and hay, they make good gains and develop into heifers just as healthy as those fed more milk

Requirements of a Milk Replacement. To give good results, a milk replacement must be nutritionally adequate, palatable, easy to use and economical

Nutritionally Adequate To be nutritionally adequate a milk replacement must supply sufficient energy, protein of high quality, minerals and vitamins The ingredients should be low in fiber and be highly digestible It is desirable that part of the protein come from animal sources, such as dry milk with its high-quality protein Another animal product often used is blood flour, as it supplies a high-quality protein that tends to

prevent nutritional scours Calcium and phosphorus should be supplied, as well as iodine, iron, copper, cobalt, and manganese when they are needed Vitamin A or carotene is needed and is generally supplied by feeding reinforced cod liver oil or a stabalized vitamin A feed When the calves start to consume hay they will get an ample supply of carotene, provided that the hay is green and leafy Vitamin D is also needed and will be supplied in the reinforced cod liver oil or by adding irradiated yeast to the ration

Vitamins of the B complex group (thiamine, riboflavin, biotin, pantothenic acid, and others) are required by calves during the period before rumination, when the simple stomach type of di gestion is in operation Milk by products and most of the grains supply these vitamins, but additional supplies are sometimes added in the form of brewer's dried yeast

The recommended daily allowance for dairy calves as formu lated by the National Research Council * is given in Table XLIX

TABLE XLIX

RECOMMENDED DAILY ALLOWANCES FOR DAIRY CALVES
(Based on Air Dry Feed Containing 90 Per Cent Dry Matter)

Body Weight, pounds	Expected Gain: Small Breeds pounds	Expected Gain: Large Breeds pounds	Daily Allowances per Animal: Total Feed pounds	Dig Protein pound	T D N, pounds	Ca, gm	P, gm	Carotene mg	Vitamin D, I U
50	0 5		0 9	0 20	1	4	3	6	200
100	1	0 8	2	0 40	2	8	6	6	400
150	1 3	1 4	4	0 50	3	12	8	9	600
200	1 4	1 6	6	0 00	4	16	11	12	800

PALATABLE Milk replacements must be composed of feeds that are palatable to the calf Otherwise, it may not consume sufficient to supply its requirements even though all essential dietary factors are present

EASY TO USE If the milk replacement is to be mixed with water and fed as a liquid it should contain only such ingredients and be of such a consistency that a part of it will go into solution

* *National Research Council,* 1950

and the remainder remain in suspension for a period of time sufficient for the calf to consume it. Ingredients that are not easily mixed with the water but settle to the bottom are not satisfactory

ECONOMICAL. Unless the cost of milk replacement is less than the feed that it replaces it has not filled a need The value of feeding it will depend upon the price of the milk that is saved and the cost of the milk replacement.

TABLE L

CALCULATED SAVING BY USING MILK REPLACEMENTS

Selling Price of Milk 100 pounds	Value of 250 Pounds of Milk	Cost of 40 Pounds Milk Replacement at 12 Cents per Pound	Saving per Calf	Cost of 40 Pounds Milk Replacement at 16 Cents per Pound	Saving per Calf
\$2 00	\$ 5 00	\$4 80	\$ 0 20	\$6 40	−\$ 1 40
3 00	7 50	4 80	2 70	6 40	1 10
4 00	10 00	4 80	5 20	6 40	3 60
5 00	12 50	4 80	7 70	6 40	6 10
6 00	15 00	4 80	10 20	6 40	8 60
7 00	17 50	4 80	12 70	6 40	11 10

Table L shows the calculated gain or loss of feeding milk replacement when its cost is 12 cents and 16 cents per pound over the value of the whole milk at varying selling prices with the assumption that 40 pounds of the milk replacement will save 250 pounds of whole milk.

The following formula for a milk replacement which has proven quite satisfactory is one of several developed by the Pennsylvania Experiment Station *

This ration should be fed at the rate of 1 pound per day until the calf is 8 weeks of age A calf starter is fed in conjunction with it. The milk replacement is discontinued at 8 weeks of age and the starter is continued for 16 weeks Good-quality alfalfa hay should be fed

* *J Dairy Sci* 32 956

Pennsylvania Milk-Replacement Formula

	Pounds
Dried skim milk	50.00
Dried whey	10.00
Corn distiller's dried solubles	10.00
Blood flour	10.00
Dextrose	7.75
Oat flour	5.00
Brewer's dried yeast	4.90
Irradiated yeast	0.10
Stabilized vitamin A feed (220,000 USP units/pound)	2.20
Minerals (Ca, P, Fe, Cu, Mn, Co)	0.042

RUMEN INOCULATION

Digestion in the calf differs from that of the cow because of the difference in the size and function of the four compartments of the stomach. In the young calf the omasum and abomasum have twice the capacity of the rumen and reticulum. In the mature cow the capacity of the omasum and abomasum is only about one-sixth that of the other two stomachs. The young calf's stomach is not well adapted for coarse feeds but calves should be fed hay as soon as possible since they seem to develop better when they consume some hay. The Ohio Experiment Station [°] found that calves would ruminate at an earlier age and that some of the difficulties of calf raising disappeared when they were inoculated with the cud material taken from a healthy cow. The cud material is secured from the cow's mouth during rumination. A quiet cow is selected and placed in her stall. The operator stands alongside her head and waits until she is ruminating normally. After the sequence is determined, he waits until the cow has regurgitated the cud and starts mastication; then he catches her by the nose with one hand and reaches the other hand into the side of the mouth and secures some of the cud. A small amount of this is placed in the calf's mouth so that it can swallow it. The cud is teeming with rumen organisms, such as bacteria, protozoa, and other minute forms of life. When the calves are kept in the stall with their dams or are kept

° *J. Dairy Sci.*, 31:1011 and 1055.

in stalls with older calves they seem to pick up the organisms They may get them by eating the feed picked over by older cattle

The inoculation of the rumen with these organisms at an early age appears to stimulate the eating of hay or grass, and to increase the digestibility of feeds eaten by the calf Calves that are inoculated usually show a sleeker coat and appear more thrifty than calves that are not inoculated They are said to consume more roughage than do those which have not been inoculated

Antibiotics. The use of antibiotics in calf rations has been advocated by several workers Aureomycin has been fed by several workers * and has resulted in increased growth and a lower incidence of scouring The greatest increase in growth is secured during the first 8 to 10 weeks of the calf's life Other antibiotics are receiving attention in dairy-calf nutrition research

OTHER CONSIDERATIONS IN CALF RAISING

Salt and Water. Most feeders add some salt to the grain ration The demand for salt, however, is not great up to the time the calves reach the age of 6 months When they receive an ample supply of milk, water is not so important until 6 or 7 weeks of age When milk feeding is decreased or discontinued, sufficient water should be supplied the calf to compensate for that in the milk. Water must be supplied in adequate amounts, and probably the best way to furnish it is by means of water cups, where the calves can supply themselves according to their desires Calves seem to differ greatly in the amount of water consumed Heifers kept under the same conditions and fed the same rations have been known to vary as much as 40 to 50 pounds per day in their water consumption There is a relationship † between body weight and water consumption Dry matter intake affects the amount of water consumed

Stalls and Ties for Calves. When the newborn calf is removed from the mother it should first be put in an individual stall This stall should contain about 25 square feet of space Thus

* *J Dairy Sci*, 34 500 and 653 and 35 493

† *J Dairy Sci* 17 249

isolated, the calf can be taught to drink and kept from sucking other calves. Some dairymen prefer to keep their calves in individual stalls throughout the milk-feeding period. Often, several calves are kept together in a larger calf pen. This pen should be provided with ties so that the calves can be fastened while being fed, to insure that each one receives its proper amount of feed. Each calf should be fed individually, since some are fast feeders and others are slow.

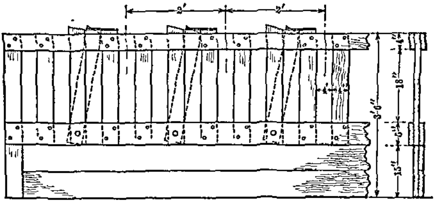

FIG. 33. Plan for wooden stanchions for calves.

Keeping Pens Clean. Calves should always have clean pens. A great deal of liquid is excreted by a calf. Damp beds are the cause of many calf troubles. Any kind of clean bedding is suitable if it is provided in sufficient amounts.

It is also advisable to give the pens a thorough cleaning and disinfecting before new calves are put in them. A good disinfectant is a 5 per cent solution of crude carbolic acid. Creolin or lysol can be used in 3 to 5 per cent solutions and are satisfactory disinfectants.

A raised floor in the calf stall, made of wooden slats or metal screen, will aid in keeping the pen dry. The liquid drains through the bedding and false floor, leaving a drier and cleaner stall. Less bedding is required.

Ventilation and Temperature. A young calf must be protected from drafts. It can withstand cold temperatures, such as encountered in loose housing, when there are no drafts if it is protected from rain and snow. When the calf barn is closed tightly, sufficient ventilation, to keep the barn dry, is essential.

Exercise. Calf pens should be provided with exercise yards. Although the young calf does not require a large amount of exercise, it should have a place of sufficient size for that purpose. Direct sunlight, as has already been noted, is an effective aid in preventing rickets; thus for calves over 2 months of age it is well to provide some clean lots into which they are turned on sunny days. The yard should also be provided with shade. A well-shaded pasture, near the buildings, in which the calves can graze and also exercise, is valuable. Feedboxes can be erected in the pasture and the calves fed there. Calves less than 6

Fig. 34. Calves on short pasture need grain and silage or hay.

months of age cannot be expected to receive very much of their feed from pasture.

Fall or Spring Calves. The fall calf is fed milk and other expensive types of feed during the winter and then is turned out to pasture in the spring. The spring calf has its most expensive feeding period during the summer and must be barn fed during the first winter of its life, and does not make quite as good or as cheap gains as the fall calf. After the fall calf goes on dry feed it has only one winter feeding to go through before freshening, whereas the spring calf has two. As a general rule, it is cheaper both in feed and labor to keep the calf on pasture as much as possible. For this reason the expense of raising the spring calf is greater than that of raising a fall calf. Many dairy farmers, however, must have cows freshen the year around and so, of course, must raise spring calves as well as fall calves.

VEAL PRODUCTION

The breeder of purebred cattle is able to find a market for his surplus heifer calves and his better bull calves The man who keeps grades does not have a market for his bull calves or for some of the poorer heifer calves except through the veal market Many are sold at birth, but in most states it is against the law to kill calves for veal under a certain age A calf killed for veal at an early age is known as a "bob veal" Many times these surplus calves can be sold at 2 to 3 days of age to farmers who keep a few cows which they use as nurse cows for growing veals

Top grade veals can only be grown by liberal feeding of whole milk, either by the nurse cow method or by hand feeding

If milk is not very high in price, calves may be raised for veal In general, where whole-milk feeding is practiced in raising veal, 10 pounds of whole milk is required to produce 1 pound of veal The market seems to demand veal from 4 to 8 weeks old and from 150 to 200 pounds in weight Whether it will pay to raise veal depends not only upon the cost of milk and the price of veal but also upon the initial size of the calf For example, a calf that weighed 100 pounds at birth would need to gain only 50 pounds to reach the desired 150 pounds This would require around 500 pounds of milk A calf weighing 60 pounds at birth would need to gain 90 pounds to reach the weight of 150 pounds, and 900 pounds of milk would be required Thus, the latter calf would require almost twice as much milk as the first calf to reach the required size

Table LI shows the profit or loss over the value of milk with three variables the weight of the calf at birth, the price of milk, and the price of veal

STANDARD MANAGEMENT PRACTICES

The Nutrition Council of the American Feed Manufacturers' Association * made a study of available research on various practices of management for the raising of dairy calves These have

* *Rept Nutr Council Am Feed Mfg Assoc* (May 9, 1951)

TABLE LI

AVERAGE RETURNS AT VARIOUS PRICES FOR MILK AND VEAL, AND WITH DIFFERENT BIRTH WEIGHTS (CALCULATED ON BASIS OF 150 POUNDS VEAL)

Birth Weight	Amount of Milk to Make 150 Pounds Veal	Profit or Loss over Value of Milk			
		Milk per 100 pounds	\$3.00	\$4.00	\$5.00
		Veal per Pound	0.15	0.20	0.30
40	1100		\$−10.50	\$−14.00	\$−10.00
60	900		−4.50	−6.00	0.00
80	700		1.50	2.00	10.00
90	600		4.50	6.00	15.00
100	500		7.50	10.00	20.00

been summarized into twenty-five recommendations, and are listed below in their entirety.

Housing Calves. (1) Dairy calves should be raised separately—one calf to a pen for at least 1 week after milk or milk substitute is discontinued. (2) Calves may be raised in groups beginning one week after milk or milk substitute is discontinued. (3) Ten calves should be the maximum number raised in one group, provided that floor and feeding space is adequate and calves are liberally fed. (4) The maximum age difference between calves in any group should not exceed 2 months. It is important to see that all calves are actually eating their fair share.

Space Needs. (5) Minimum pen size for individual calves is 24 square feet. (6) Minimum pen size for calves in groups with no outside run is 30 square feet per calf.

Watering Devices. (7) Automatic drinking cups are preferred for calf waterers. Where pails are used for watering, they should be kept clean and well filled with fresh water. (8) Automatic drinking cups are preferred for calves housed in pen groups. Where watering tanks are used for calves in outside runs, the water should be fresh and the tanks kept in sanitary condition. (9) Top of drinking cups for calves should be 20 inches from the floor. (10) Watering equipment for calves in individual pens should be located at a front corner of the pen away from the feed. (11) Watering equipment for calves in groups should

be at front corners of the pen or an outside tank (12) Provide two automatic drinking cups when more than five calves are housed per pen

Feedboxes. (13) Calf-ration feedbox for the individual pens should be 8 x 10 x 6 inches deep It is desirable to make boxes removable for cleaning (14) When calves are raised in groups, calf ration feedboxes should be 10 x 6 inches deep, allowing 2 feet per calf Two troughs per pen are preferred

Management Recommendations. (15) Top of calf ration feedboxes should be 20 inches from floor (16) Locate calf ration feedboxes at front of individual pens away from waterer (17) For calves fed in groups, locate feedboxes where convenient but away from waterers

Pen Construction. (18) Solid partitions between individual calf pens will reduce chilling drafts

Temperature. (19) Desirable pen temperature range for raising young calves is 50 to 75°F Keep temperature as uniform as practicable Sudden variations in temperature are particularly dangerous Dryness in pen is important because dampness intensifies cold

Feeding. (20) There is no minimum time to leave the vigorous newborn calf with the cow It is very important that the calf gets colostrum the first 3 days either by nursing or drinking (21) Young calves may be taught to drink from a pail or a nipple-feeding device It is important that pails or other calf-feeding equipment be kept scrupulously clean at all times to avoid digestive disturbance (22) Calves may be turned out to pasture as soon as practicable after 4 months of age They should continue to get their usual feed and have access to salt, water and shade (23) High-quality hay should be fed to calves from the start (24) Ensilage may be fed after calves are 6 months old (25) A safe age at which whole milk or milk substitute may be replaced entirely by a suitable calf starter, grain mixture and roughage will depend on the kind of start the calf had and its vigor Usually 6 weeks can be considered a safe age for this change, though healthy vigorous calves may be changed as much as 2 weeks earlier with good results

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19

Care and Development of the Dairy Heifer

GROWTH

Growth is one of the oldest of phenomena, yet we have hardly begun to understand the principles underlying it. Growth * has been defined as the increase in volume in a living material.

It is the result of three processes: namely, multiplication of cells, enlargement of cells, and deposition of intercellular substance, the first two being more potent than the third. Minot † states that the impulse to grow is imparted at the time of fertilization of the ovum and that the growth of the germ of the animal, from the time of fertilization to that of birth, represents an increase of over 5 million per cent, the gain at first being 1000 per cent in a day. He calculated that 98 per cent of the growth impulse is used up at the time of birth.

Causes of Growth. Just as there are two factors related to milk production, so there are two factors related to growth, one internal and the other external. It has been observed that animals will often continue to grow even under adverse conditions of nutrition. The impulse to grow, which is set free at the fertilization of the ovum, will continue until the full size has been reached, unless adverse conditions are encountered. The cause of this growth stimulus is thought to be the hormones or secretions of the endocrine glands. The endocrine glands that are thought to be related to growth are the pituitary body, the thyroid gland, the thymus gland, the suprarenal body, the pineal body, and the ovaries and testes. The internal factors are not under the control of the feeder to any great extent, and they will

* *Experimental Zoology*, Morgan

† *The Problem of Age, Growth, and Death*, Minot.

continue to act even under adverse conditions They seem to influence the growth of the skeleton to a greater extent than growth of the fleshy part of the body The skeleton has a stronger tendency to grow than the fleshy part Waters * found that animals that were fed even less than a maintenance ration continued to make skeleton growth for six months while the fleshy part did not gain to any extent

The external factors depend upon the nutrition and handling of the animal, that is, they are dependent upon conditions under the herdsman s control If calves are not supplied with all the nutrients necessary for growth they will fail to reach their full size

Limits of Growth It is thought † that the variation in the growth of different animals is largely inherited In other words an animal inherits the capacity to reach a certain size if given favorable conditions and it will not grow any larger even under the most favorable conditions of care and feed However, if the conditions are adverse, the animal may never reach this maximum size Animals are able to overcome adverse conditions however, if these are not continued for too long a time and not too severe It has been shown ‡ that after a period of retarded growth calves will grow at a faster rate than normal when the conditions are again improved, and they will continue to grow for a longer period of time This may compensate for the loss due to retarded growth unless the retardation is continued for too long a time

Measuring Growth Since the fleshy part of the animal does not gain at the same rate as the skeleton, it can be seen that growth cannot be measured by the weight alone Eckles § decided, after a study of several measurements that the height at the withers would be the easiest and most satisfactory measure of the growth of the skeleton Thus two units are commonly used for measuring growth gain in live weight and gain in height at the withers

* *Soc Prom Agr Sci* 29
† *Biochem Bul* 3 156
‡ *Mo Res Bul* 31
§ *Mo Res Bul* 36

Normal Growth In order to obtain information on the weight and height at withers of heifers fed according to good dairy practice, all calves and heifers at the Missouri Station were weighed and measured From the data collected, together with similar data collected from other sources, a normal growth table for the Holstein, Jersey, Ayrshire, and Guernsey breeds was formulated [*] This is given in Table LII

This table can be used by breeders to determine whether or not their calves and heifers are growing normally If scales are at hand the calves or heifers can be weighed at intervals, and their height at withers can easily be determined

Table LII also shows that there is a distinct difference between the different breeds in the time that their skeleton growth is complete The Jersey has practically its full skeleton growth at the age of 4 years, but the Holstein continues to grow in skeleton until it is almost 5 years of age The other breeds mature at ages between these two extremes The growth in the fleshy part, as denoted by weight, does not reach its maximum until about 2 years after the skeleton has ceased to grow

Most farms possess no available means for weighing animals A rather close correlation exists between the heart girth measurement and body weight The measurement is taken just back of the forelegs The Bureau of Dairy Industry, United States Department of Agriculture, prepared the data in Table LIII after many measurements and weighings Cattle in high condition will weigh more than the table indicates and thin animals will weigh less Other variations will be found, for example, long, slender animals will overweigh the table and short, chunky types of animals will underweigh A dairyman can measure his cattle and use this table when it is not convenient actually to weigh them

FEEDING THE DAIRY HEIFER

Opinion as to the best manner in which to feed dairy heifers is not completely unified After the heifer is past the danger stage that is always present with young calves, and before she

[*] *Mo Exp Sta Bul* 336

TABLE LII

Normal Growth in Weight and Height of Dairy Heifers

Age Month	Ayrshire		Holstein		Jersey		Guernsey	
	Weight, pounds	Height at Withers, inches	Weight, pounds	Height at Withers, inches	Weight pounds	Height at Withers, inches	Weight pounds	Height at Withers, inches
Birth	72	27.6	90	29.1	55	25.7	65	26.6
1	89	28.6	112	30.6	67	27.0	77	28.2
2	119	30.2	148	32.3	90	28.9	102	29.8
3	158	31.9	193	34.3	121	30.6	133	31.6
4	198	34.0	243	36.2	158	32.6	173	33.5
5	245	35.5	297	37.7	189	34.5	216	35.3
6	293	37.2	355	39.7	243	36.2	260	36.9
7	344	38.5	410	41.1	286	37.7	305	38.4
8	389	39.9	462	42.3	324	39.0	350	39.9
9	433	40.9	509	43.5	360	40.1	389	40.9
10	469	41.7	552	44.4	393	40.9	427	41.7
11	502	42.5	593	45.3	420	41.7	459	42.6
12	538	43.2	632	46.0	450	42.2	490	43.3
13	577	44.0	671	46.7	479	42.8	524	43.9
14	611	44.8	705	47.3	507	43.3	556	44.6
15	638	45.1	746	47.9	530	43.9	584	45.0
16	669	45.7	782	48.5	558	44.4	605	45.3
17	697	46.2	809	48.9	580	44.7	634	45.9
18	725	46.5	845	49.3	601	45.2	663	46.4
19	758	46.8	878	49.8	622	45.5	686	46.7
20	793	47.4	912	50.2	642	45.9	712	47.0
21	818	47.6	952	50.6	665	46.2	737	47.3
22	844	47.8	986	51.0	684	46.4	763	47.7
23	871	48.1	1024	51.3	708	46.7	788	47.9
24	902	48.3	1065	51.7	733	46.9	818	48.0
30	945	48.3	1120	52.5	824	47.9	880	49.3
36	968	48.7	1165	53.0	855	48.2	901	49.9
48	1035	50.2	1232	53.3	837	48.5	990	50.4
60	1080	50.4	1330	53.6	937	49.0	1055	50.6
96	1143	49.2	1365	53.2	909	47.7	1070	49.6

TABLE LIII

ESTIMATING THE WEIGHT OF DAIRY COWS AND GROWING YOUNG STOCK FROM HEART GIRTH MEASUREMENTS

Heart Girth, inches	Weight, pounds	Heart Girth, inches	Weight, pounds	Heart Girth, inches	Weight, pounds	Heart Girth, inches	Weight, pounds
26	80	41	224	56	526	71	1027
27	84	42	240	57	552	72	1069
28	89	43	257	58	579	73	1111
29	96	44	275	59	607	74	1153
30	101	45	294	60	637	75	1197
31	108	46	314	61	668	76	1241
32	118	47	334	62	700	77	1285
33	128	48	354	63	732	78	1331
34	138	49	374	64	766	79	1377
35	148	50	394	65	800	80	1423
36	158	51	414	66	835	81	1469
37	168	52	434	67	871	82	1515
38	180	53	456	68	908	83	1561
39	192	54	478	69	947	84	1607
40	208	55	501	70	987	85	1653

has reached a productive stage, the tendency has been to rough her through with as little care and feed as possible Before taking up the method of feeding, it is necessary to understand the effects of nutrition during this period upon the growth of the dairy heifer, upon her dairy type, upon her sexual maturity, and upon the other factors that may affect her future usefulness

Effect of Ration upon Growth and Size of Animal Several studies have been made upon the development of heifers during the period from the age of 6 months to freshening time One of the most extensive was carried on at the Missouri Experiment Station * It covered a period of 8 years and entailed forty animals The heifers were divided into two main groups One group was fed skim milk for the first 6 months, and all the grain and hay they could consume from birth until the time of first calving, the other group was fed skim milk for the first 6 months, and then only pasture or hay until the time of first calving Weights and measurements were taken monthly Half of each

* *Mo Exp Sta Bul* 135 and *Mo Res Bul* 31

group were bred early and the other half were bred late, so that data in regard to breeding could be obtained

During the growing period the heavy ration caused a much more rapid growth, both in skeleton and in flesh, especially during the months of rapid development Later, the heifers fed the heavy ration became much fatter Those fed the light ration grew less rapidly but continued to grow for a longer period of time, never, however, reaching the size of the heavily fed group The weights always showed a much greater difference than the skeleton measurements.

TABLE LIV

THE EFFECTS OF RATION UPON GROWTH AND WEIGHT OF HEIFERS IN PERCENTAGE OF NORMAL

	Jerseys		Holsteins	
Months	Light Fed Weight	Heavy Fed Weight	Light Fed Weight	Heavy Fed Weight
6	95	99	85	120
12	80	104	73	118
18	83	128	84	130
24	84	109	88	119
	Height	Height	Height	Height
6	98	99	96	102
12	95	101	93	103
18	95	102	95	103
24	96	101	97	103

Table LIV compares the effect of rations upon skeleton growth and increase in weight in percentage of normal

EFFECT OF RATIONS FED DURING THE WINTER ON SUMMER GAINS Heifers that have been fed heavily during the winter and are then turned out into a pasture in summer usually make much smaller gains during the summer than those that have been fed lightly In experiments at the West Virginia Station * the tendency was for both the heavily and lightly fed groups to approach normal during the summer months This would indicate

* *W Va Exp Sta Bul* 232

that little is to be gained by too heavy feeding during the winter months if the heifers are to be pastured during the summer.

Effect of Ration on Dairy Type. During the growing period, the Missouri Experiment Station found that heavy rations tended toward the development of larger and somewhat coarser animals than lighter rations. When the heifers were placed on the same ration after freshening, however, the difference disappeared.

Effect of Ration on Dairy Qualities. The Missouri experimenters found some high producing cows in each group, also some medium producers and some inferior producers. Heredity exerts a stronger influence upon the dairy cow's production than the ration does, but the data show that the heifers receiving the heavier ration were slightly inferior as milkers to those receiving the light ration. The report states, "It is not probable that within the limits ordinarily found under practical conditions this factor would exert sufficient influence to be worth consideration."

Effect of Ration upon Maturity. Animals receiving a heavy ration mature sexually from two to three months earlier than those receiving a light ration. This may be an advantage in that they will come into milk somewhat earlier than the others.

Workers at the Cornell Experiment Station * fed Holstein heifers at three levels of nutrient intake. These levels were based on the Morrison standard as follows: supernormal, 140 per cent, normal, 100 per cent, and subnormal, 65 per cent. The results of their study is tabulated in Table LV.

TABLE LV

EFFECTS OF LEVELS OF FEEDING ON DAIRY HEIFERS

Level of Feeding, per cent	Body Weight at 2 Years, pounds	Height at Withers, inches	Heart Girth inches	Age of First Estrus months	Number of Services per Conception
140	1264	52.0	76.9	9.4	1.33
100	1020	50.0	69.6	11.3	1.22
65	700	47.5	62.6	17.3	1.56

Conclusions. From the results noted above, we may conclude that heifers should be fed in such a way that they will make

* *J. Dairy Sci.*, 34:510.

good gains, in order that they may obtain their full size There seems to be no benefit, however, from feeding heifers too heavily They should be so fed that they will reach their maximum growth as determined by their inheritance The cows that have made the largest records for both milk and butterfat have invariably been the large animals of the breed It is true that the stimulation to produce milk may be inherited independently of size, nevertheless, an undersized cow is limited in her capacity to consume and digest feed and cannot compete with a larger cow even though she has inherited to an equal degree the stimulation to give milk

Turner * found an increase of 20 pounds of butterfat per cow per year for each 100 pounds additional body weight of the cow McDowell † made an analysis of the production records of more than 220,000 cows and the size of the cows He found that the larger cows produced more milk and butterfat and returned a greater profit over feed cost The relation of weight of dairy cows to their production of milk and butterfat as found by his study is shown in Table LVI

Another report ‡ showed that within the breed an increase of 100 pounds in size of cows was correlated with an increase of from 14 to 22 pounds of butterfat per year

Feeding the Heifer after Weaning from Milk Too often, dairymen make the mistake of weaning calves from milk and grain at the same time and turning them out to pasture and allowing them to graze for themselves A young heifer 6 months old will not graze enough even on good pasture to make the gains that she should For this reason it is recommended that calves be fed some grain for the first 2 or 3 months on pasture or until they become accustomed to the change of feed Spring calves should also be fed liberally at weaning time on both roughage and grain. After being weaned from milk, fall calves must be carried over two summers one winter, and usually a

* *Mo Exp Sta Res Buls* 147 and 164.

† *U.S D.A. Circ* 114.

‡ Purebred Dairy Cattle Assoc Mimeo *Size and Its Influence on Milk Production.*

TABLE LVI

RELATION OF WEIGHT OF DAIRY COWS TO PRODUCTION OF MILK AND BUTTERFAT WITH PUREBRED CATTLE

Average Weight of Cows pounds	Ayrshire		Guernsey		Holstein		Jersey	
	Milk, pounds	Butter-fat, pounds	Milk pounds	Butter fat, pounds	Milk, pounds	Butter-fat, pounds	Milk, pounds	Butter-fat, pounds
600							5176	266
700			5785	276			5754	303
800	6235	247	6018	294	7,434	260	6142	320
900	6154	241	6314	309	8,357	288	6422	335
1000	7005	276	6382	315	8,706	298	6670	346
1100	7723	304	6648	325	9,156	311	6857	352
1200	7704	302	6782	334	9 718	328	7162	357
1300	9451	361	6967	328	10,311	347		
1400					10,560	355		
1500					10,922	369		
1600					11,578	392		

part of the second winter, before they freshen Pasture is by far the most economical means of feeding heifers, and when it is available it should be used to a large extent After a heifer is 9 or 10 months of age she will make satisfactory gains on pasture alone, until a few months previous to the time she is due to freshen

When calves are first turned on to pasture, they should continue to get some dry roughage for several days, in addition to grain A sudden change from dry feed to pasture causes the calves to become very loose and to lose considerable weight before they are accustomed to the grass

The grazing season for heifers should be made as long as possible by the use of improved pastures and special pasture crops

Winter Feeding Yearling Heifers

Heifers Under a Year of Age Need Special Care Heifers under a year of age cannot consume sufficient nutrients in the form of roughages to make normal growth They will need from 2 to 5 pounds of a grain ration, the amount and kind depending upon the kind of roughage they are being fed They cannot utilize low quality roughages as well as can yearling heifers, which have developed greater rumen capacity They, therefore, should be fed good quality roughage with the grain

Feeding Heifers during the Winter The basis for winter feeding of heifers should be good quality roughage, preferably silage and legume hay Although such feeds are ideal, nevertheless there is a general practice on many dairy farms to feed the best quality roughages to the calves and the milking herd, leaving the poorer-quality hay and the stover to feed to the heifers This may be the most economical method of using the available feed supply, and, within limits, the heifer can utilize these lower grades of roughage if they are supplemented with concentrates that will fill the needs for protein, total digestible nutrients, and other requirements However, the feeder should be sure that these requirements are met, as heifers should be fed so that they will be kept growing normally at all times

WHERE LEGUME HAY AND SILAGES ARE AVAILABLE. When both legume hay and silage are available the heifers over a year of age will be able to consume sufficient to meet their full nutritive requirements They should be fed as much hay as they will consume and from 10 to 20 pounds of silage per day If, however, the hay and silage are not of top quality, or if the heifers are not fed all that they will eat 2 pounds of corn or other feeds should be fed daily per heifer

WHEN LEGUME HAY OR LEGUME SILAGE ONLY IS AVAILABLE. When only good-quality legume hay is available heifers will make fairly normal growth when fed all that they can eat. This is true also with legume silage The quality of the hay must be very good or the animals will not eat sufficient to fulfill their requirements for energy If the hay is not of top quality, about 2 pounds of corn or other feeds should be fed daily

WHEN ONLY CORN OR SORGHUM SILAGE IS AVAILABLE A heifer cannot consume sufficient corn silage or sorghum silage to fulfill her protein requirements but can consume sufficient to meet her energy requirements Under such conditions, 2 or 3 pounds of a concentrate should be fed daily to each heifer One fourth of the concentrate should be a high protein supplement, such as linseed oil meal, soybean oil meal, cottonseed oil meal, or similar feeds high in protein The remainder of the ration may be corn, oats, bran, or other more economical feeds

WHEN NONLEGUME ROUGHAGES ONLY ARE AVAILABLE When nonlegume hays or poor quality legume hay, and corn stover or straw are the only roughage available, it would be wise to purchase some legume hay and feed one half legume hay with the poor roughage With this should be fed about 3 pounds of a grain ration consisting of 2 parts corn or other grains and 1 part high protein feed

If legume hay cannot be secured, more grain must be fed for even fair results The heifers should be fed about 5 pounds daily of a grain mixture made of 1 part high protein concentrate and 2 parts farm grains Not only are such roughages low in nutrients and digestibility, but they are unpalatable and the heifers will not consume as much of them as they will of good quality roughages

Heifers Should Be Given Extra Feed before Freshening Heifers that are within 3 months of freshening need additional feed They should be fed about 2 to 5 pounds of a low protein grain ration, the exact amount depending upon the condition of the heifer and the kinds of roughages that they are being fed The object of this extra feeding is to have the heifers in good flesh when they drop their calf since they will usually produce more milk if they are in good flesh at time of freshening The heifers should be handled in the same manner as dry and fresh ening cows

AGE OF BREEDING

Effects of Early Breeding on Size of Animal The age at which heifers should be bred depends upon several factors In its studies on the subject, the Missouri Station * found that,

* *Mo Exp Sta Bul* 135 and *Mo Res Bul* 31

whereas gestation in itself did not affect the rate of growth to any great extent, lactation had a decided influence upon it. Heifers during lactation did not grow nearly as fast as did unbred or pregnant heifers of the same age and breed. As a result, heifers that calved when 20 to 24 months of age did not average so large at maturity as those that calved at a later age. The most decided effect upon the size of the mature dairy cow is produced when the heifer is fed a light ration during the growing period and at the same time bred to calve early. This, no doubt, is one of the main reasons why numerous undersized cows are found in many herds.

Effect of Early Calving on Milk Production. Heifers that are well grown and somewhat mature will produce more during the first lactation than heifers freshening at a younger age. Table LXIII, in Chapter 22, gives age-conversion factors that indicate the average differences in production due to age. But what effect will late or early calving have on the production in later lactations and on lifetime production? A heifer that does not calve for the first time until she is 36 months of age has lost a year's production compared to the one that calved at 24 months. Will higher yearly production compensate for this?

Table LVII shows the influence of age at first calving on the

TABLE LVII

BUTTERFAT PRODUCTION FOR COWS OF DIFFERENT AGES AT FIRST CALVING

Age at First Calving, months	No. of Cows	Lactation 1st	2nd	3rd	4th	5th	Total for 5 Lactations	Age at End of 5th Lactation, months
18–21	10	266	363	383	422	434	1868	84
22–23	14	335	353	433	439	403	1963	86
24–25	56	330	360	402	406	414	1912	84
26–27	58	311	333	395	415	421	1875	87
28–29	36	327	360	399	399	415	1900	89
30–31	15	355	352	403	427	429	1966	92
32–33	24	373	365	414	425	423	2000	96
34–35	23	333	417	449	457	392	2048	98
36–42	17	372	399	426	428	391	2016	103
	Mean	331	362	408	419	414	1934	

production from the first through the fifth lactation as found at the Wisconsin Station *

The greatest difference in production was in the first lactation Heifers that were over 31 months of age at first calving were generally higher during the first four lactations, but decreased in production during the fifth lactation Although they had slightly more total production for the five lactations, the difference was not great It would not compensate for the cost of maintaining the heifer for the longer period before first calving

Since the study did not go beyond the fifth lactation, it does not give the relationship with lifetime production nor with longevity Some dairymen believe that late calving heifers do not remain in the herd as long as those calving at an average age

These workers found the total production to 84 months of age for the same cows Their results are tabulated in Table LVIII

TABLE LVIII

AGE OF FIRST CALVING AND TOTAL PRODUCTION TO 84 MONTHS OF AGE (POUNDS BUTTERFAT)

	Age at First Calving months								
	18–21	22–23	24–25	26 27	28–29	30 31	32 33	34 35	36–42
Production to 84 months of age in pounds of butterfat	1870	1930	1910	1810	1760	1790	1580	1540	1490

Except for those calving at the very young age of less than 21 months, the younger calving ages gave a greater total production to 84 months of age than the next older calving group

In a study of the dairy herd at the Pennsylvania Station † data were collected on forty grade Guernsey cows that had milked over five lactation periods From these data Table LIX was compiled to show the effect of age of calving upon later production

This study seems to indicate that later calving than is usually practiced gives higher production In consideration of the extra

* *Proc Am Soc Animal Production* (1936)
† *Pa Exp Sta Rept* (1915–1916)

TABLE LIX

EFFECT OF AGE OF CALVING ON FAT PRODUCTION

Age of Calving months	Average Production of Fat, pounds
18–24	261
24–30	268
30–36	278
36–40	252

cost and care, however, it may not be advantageous to keep the heifers to this age before breeding.

The heifers calving after 36 months of age produced less than any of the earlier-calving heifers

Effect of Early Calving on Type Eckles found that early calving tended toward a smaller and more refined type of cow than late calving.

Conclusions From a consideration of the above it would seem that the age of first calving should be given some consideration. Calving at too early an age is detrimental to the size and later production of an animal but not much advantage is to be gained by having the heifers freshen at too late an age Heifers that have been poorly fed or are small for any reason should not be bred as early as those that are well grown On the other hand those that have been heavily fed especially with liberal grain feeding throughout their growing period should be bred early The time of breeding heifers should be based on size as well as on age

Heifers that are normal in size should be bred to freshen at the following ages

	Months
Jerseys	24–27
Guernseys	26–29
Ayrshires	27–30
Holsteins	27–30
Brown Swiss	28–32

HOUSING THE HEIFER

Since the heifer is unproductive she should be maintained as cheaply as possible The barn in which heifers are kept need

not be expensive, but it should be dry and convenient. One of the best types of shelters for heifers is an open shed in which they can be protected from winds and rains. Many think that such quarters are more healthful than closed barns. Such a shed can be cheaply and easily built.

It is often desirable to have stanchions or some means of tying the heifers while eating, otherwise, the larger ones may consume more than their share, whereas some of the smaller ones go hungry and hence will not make normal growth. This difficulty may be obviated by dividing the heifers into small groups of even sized heifers.

TABLE LX

RECOMMENDED DAILY ALLOWANCES FOR GROWING DAIRY HEIFERS *

Body Weight, pounds	Digestible Protein, pounds	T D N, pounds	Ca, gm	P, gm	Carotene, mg
50	0.20	1	4	3	6
100	0.40	2	8	6	6
150	0.50	3	12	8	9
200	0.60	4	16	11	12
400	0.80	6.5	20	15	24
600	0.85	8.5	18	15	36
800	0.90	10	16	15	48
1000	0.95	11	15	15	60
1200	1.00	12	15	15	72

* Recommended Nutrient allowances for Dairy Cattle, *Nat. Research Council*.

Feeding Standards for Growing Dairy Animals. Table LX shows the requirements for growing dairy heifers of various sizes.

An 18 month old Holstein heifer weighing 850 pounds would require about 0.91 pound of digestible protein and 10.25 pounds of total digestible nutrients. It would require 20 pounds of good-quality legume hay or 10 pounds of the same hay and 30 pounds of corn silage to supply the above requirements. Fifteen pounds of mixed hay and 4 pounds of a grain mixture would suffice. A 14 month old Jersey heifer weighing 500 pounds would need 0.82 pound of digestible protein and 7.5 pounds of total digest-

ible nutrients Ten pounds of clover hay and 3 pounds of a grain mixture would supply the requirements

The most prevalent type of poor feeding of dairy heifers is merely insufficient feed A heifer should be grown sufficiently large to take her place in the milking barn after calving and give a good account of herself at the pail This is of more importance to the dairyman than it is to produce the heifer at a slightly lower cost.

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20

Feeding and Care of the Sire

Less is known about the feeding and care of the herd sire than of the dairy cow or the calves and heifers, probably because in the past there was usually only one bull on a farm, so that the number of them to be cared for and fed was small as compared to cows and heifers. Furthermore, since the bulls were not productive, the means of knowing when they were being properly fed were not so reliable.

Research studies, however, have subsequently been made on the nutrition of breeding bulls. With breeding studs, a large number of bulls are maintained at one place, and it is possible to feed various types of rations and various levels of feeding to bulls maintained under the same conditions. Also, the study of the semen both in the laboratory and in the field furnishes a measure of results obtained.

Feeding the Bull during the Growing Period. Since the bull is going to be used at the head of a herd when he is mature, it is necessary that he be given every possible chance to develop in size to the full extent of his inheritance. A stunted bull that never reaches its maximum size may be just as good a breeder as a well grown one but there is no way to tell that the smallness is not due to inheritance, and the animal is looked upon with disfavor by those who do not know his history. For this reason the bull should be well fed from birth. Table LXI shows the normal growth of bulls of the various breeds, according to the Missouri Experiment Station.*

For the first 6 months of his life, the young bull should receive

* *Mo. Exp. Sta. Bul.* 336.

TABLE LXI

NORMAL GROWTH IN WEIGHT AND HEIGHT OF DAIRY BULLS

Age, months	Ayrshire		Holstein		Jersey		Guernsey	
	Weight, pounds	Height at Withers, inches	Weight, pounds	Height at Withers inches	Weight, pounds	Height at Withers, inches	Weight, pounds	Height at Withers inches
Birth	81	27 5	94	29 4	60	26 2	71	27 7
1	101	28 4	125	31 2	78	27 9	87	29 3
2	133	29 7	164	33 2	104	29 7	113	30 6
3	173	32 7	214	34 8	141	31 5	147	32 4
4	217	34 5	269	36 4	184	33 6	190	34 2
5	267	36 1	336	38 8	233	35 5	237	36 1
6	321	37 9	399	40 5	282	37 2	291	37 8
7	378	39 4	456	41 9	326	38 4	345	39 2
8	433	40 2	514	43 1	370	39 5	401	40 3
9	488	41 5	563	44 2	410	40 4	443	41 5
10	532	42 2	620	45 1	452	41 4	494	42 5
11	558	42 8	683	46 4	497	42 7	547	43 3
12	599	43 3	741	47 5	531	43 0	609	44 5
18	751	46 4	1176	52 2	745	47 5		
24	990	48 1	1438	55 9	969	50 3		

the same care and feed as a well cared for heifer Since he is to head the herd, the item of cost should not be considered as much as in the raising of a heifer He should be fed in such a way that he will always be thrifty and growthy At this time they should be fed a good grain ration containing from 12 to 15 per cent protein and practically all the good legume hay that they desire Almost any combination of grain is satisfactory, although, if nonlegume hays are fed, a ration higher in protein is necessary In that case a ration similar to 2 below will be recommended Grain mixtures which have been recommended for feeding at this time are as follows

Ration 1	Ration 2
5 parts wheat bran	2 parts corn or barley
4 parts ground oats	3 parts oats
1 part linseed meal	3 parts bran
	2 parts linseed meal

Most feeders use the same grain mixture which is fed to the dairy heifers The young bull should be fed from 4 to 8 pounds of grain daily, depending upon his size and the amount of service he is allowed The amount of legume hay which a bull will consume depends upon his size, a mature bull will eat as much as 1 pound of hay daily per 100 pounds of body weight There is a belief among dairymen that silage fed to bulls develops paunchiness and reduces their potency. Research * indicates, however, that bulls may consume grass silage in amounts up to 4 pounds per 100 pounds of body weight without harmful effects.

Olson † fed bulls on rations supplying 70, 100, and 130 per cent of the T D N recommended by the Morrison's standard In one trial the bulls were placed on these levels of feeding at 8 months of age and continued to 36 months of age In another trial the study was made when they were from 27 to 64 months of age. He states, "The measurements of quantity and quality of semen generally favored the bulls fed 100 and 130 per cent of the normal ration During the first part of the trial the well-fed bulls exhibited the greatest libido Toward the end of the trial, the ability of the overweight bull to serve decreased"

Young bulls ‡ grown on rations deficient in vitamin A have been found to produce poor-quality semen or failed to breed

Feeding the Service Bull. A bull in service should not be fat but should be fed so that he is in good breeding condition It is a common belief that a fat bull lacks stamina, and that he may even become impotent from too much fat On the other hand, a bull should not be allowed to become too thin If the conditions on a farm are such that breeding is limited to one season, the bull should be so fed that he is gaining in weight

* *J Dairy Sci*, 35 949

† *J Dairy Sci*, 35 489

‡ *J Dairy Sci*, 29 522, 30 687

during this period On most farms, however, it is necessary to have cows bred to freshen the year round, a fact which naturally causes the breeding to extend over a longer period of time Bulls in such herds must be fed in much the same manner at all seasons of the year

Some dairymen feed the bull the same grain mixture that they feed the herd, on the assumption that to be in good breeding condition he should receive a reasonable amount of protein A common grain ration for the mature bull is as follows

3 parts corn meal
3 parts ground oats
3 parts wheat bran
1 part linseed meal

When the bulls are not on pasture, the importance of feeding good-quality legume hay cannot be overemphasized. It is a good feed containing abundance of protein, minerals and vitamins The practice of giving only the low grade roughages to bulls is not to be recommended

Branton * has made the following recommendation for feeding bulls used in artificial breeding. One pound of hay (or hay equivalent) and 0 4 to 0.5 pound of concentrates daily for each 100 pounds of body weight of the bull Ten per cent protein in the concentrate mixture was found to be sufficient when legume hay was fed, or 12 per cent when mixed hay was fed.

Pasture furnishes the best feed for bulls and assures ample exercise Bulls are not usually pastured, however, because of the strength of the fence required to hold a bull. The use of a two-wire, double-controlled electric fence inside a well built permanent fence is quite effective Dehorned bulls are not as destructive to fences as bulls with horns

Green feed and sunlight are beneficial to the breeding bull. It is desirable to supply some pasture for the bull if possible When pasture cannot be provided, some green feed should be cut and fed to the bull Often, the bull is the poorest fed dairy animal on the farm throughout the year, unless he has access to some pasture

* *J Dairy Sci.*, 30 1003

Bulls in a Wisconsin breeders' cooperative * fed an all roughage ration produced semen of equal fertility to semen from bulls fed grain and roughage

Experiments at the Cornell Experiment Station † did not show that, for the nutrition of bulls, animal proteins were superior to plant proteins in the production of semen or in its fertility

Teaching the Bull to Lead. When the bull calf is 5 or 6 months of age he should be separated from the heifer calves, because at that age he may become sexually mature and may breed some of the young heifers if allowed to run with them At that age, or even before, he should be taught to lead so that he may be more easily handled when older It is best to lead the bull at intervals to keep him used to being handled

Ringing the Bull. When he is 10 or 12 months of age, a bull should have a ring put in his nose The ring at this time should be of light weight and about 1½ to 2 inches in diameter It should be of some nonrusting material, such as copper or aluminum When the bull is older this ring should be replaced with a larger one, and when he is mature, a strong 3 inch brass or cannon metal ring should be used

To ring the bull, it is advisable to have him well fastened in a stanchion or stocks The opening should be made through the thin tissue of the nose with a bull nose punch, a trocar, or a self-piercing ring The ring is then put in and fastened securely by a screw Care should be taken to change the ring before it becomes too badly worn, because a weak ring is hazardous

Staffs. After the bull has a ring in his nose he should be trained to lead with a staff One should never take chances with a large bull because he may become vicious at any time Several makes of staffs are on the market, some of which are fitted with special devices designed particularly to handle vicious bulls The staff should always be used on all bulls, as it is usually the "gentle" bull that causes trouble The owner of a vicious bull is generally prepared against him

Dehorning. If the bull is to be kept in a herd where showing at fairs is not practiced, it is advisable to prevent the growth

* *J Dairy Sci*, 33 870
† *J Dairy Sci*, 32 292.

of the horns by the use of caustic or by other methods, as described previously Many seem to prefer to allow the horns to grow until the bull is about 2 years of age and then remove them They think that the bull, once having learned to use his horns, misses them and becomes much more tractable than he would be otherwise Since bulls are always more or less dangerous, it is recommended that their horns be removed, except in herds of highly developed purebreds The dehorning of a mature bull is quite an undertaking unless proper equipment is used Removing the horns may temporarily affect the potency of the bull, the large opening into the sinus that is left when bulls 2 years old or older are dehorned occasionally gives difficulty in healing and closing and may become infected

Service. A young bull should not be used regularly until 12 to 15 months of age If well grown and vigorous he may be used occasionally after 10 months of age The amount of service should be limited to not more than two services per week until the bull is 18 months old As he grows older, however, he can be given more frequent service Mature bulls may be used for as many as 150 services per year, if these are evenly distributed The number of cows that he could serve would, of course, be determined by the number of rebreedings necessary However, on most farms the breeding cannot be evenly distributed, therefore, it is usual to keep one bull to each fifty or sixty cows Young bulls should not be used too frequently as overuse may be responsible for a decline in their vigor and potency

Bulls should not be allowed to run with the herd during the breeding season One of the reasons for this is that a bull running in pasture is in contact with a cow in heat, causing dissipation on his part, a condition that brings on impotency much earlier than would otherwise occur

In artificial breeding studs, bulls are usually bred only once per week Sometimes they may be bred the second time but where bred only once they give a larger and stronger ejaculate than when used more often Nature is lavish in anticipation of reproduction and one service properly conducted is sufficient to impregnate many animals However, if a bull has not been used for some time, there is some indication that the first ejaculate may not be as good as a second one It requires careful

service to preserve a bull's breeding qualities until old age Often, when a bull reaches the age of 8 or 10 years he becomes slow in breeding and may become uncertain.

Exercise. There is some difference of opinion as to whether dairy bulls should be forced to take exercise. Many breeders have thought that bulls would keep in better physical condition and produce more and better semen if they were forced to take exercise regularly Many types of exercising devices have been constructed to force the bull to take exercise

On the other hand, since the development of artificial breeding, when large numbers of bulls are kept together in one stud, the importance of forced exercise has not been found so necessary as formerly believed In fact, many of the studs have discontinued the use of forced exercise, and the bulls are given only the exercise they secure when turned into a roomy yard Bulls should probably be allowed out in a roomy yard daily or at least 2 or 3 times each week If animals are confined in poor, cramped quarters, they may have trouble with their feet and legs Overgrown hoofs and swollen and inflamed joints resulting from too close confinement may prevent a bull from giving normal service even though his semen may be normal

Housing the Bull. Too often the bull is kept in a dark, dirty stall and is kept tied most of the time Since the bull has so much influence on the success of the herd, he should be given comfortable quarters. Although many dairymen keep the bull in a box stall in the same barn with the milking herd, most of them prefer to keep the bull in a separate barn, away from the other dairy animals The stall should be about 12 feet square It should open into a strongly fenced paddock into which the bull has free access or is turned daily The stalls and fence should be strongly built The pen should have a stanchion in which the bull can be tied during cleaning time

The bull barn need not be tightly made A good roof and a wall to keep the wind and rain off the animal are all that is necessary A certain amount of exposure will not harm the bull, provided that he has a dry, well bedded stall, free from drafts, into which to go during cold, windy, or rainy weather

Handling Vicious Bulls. It often occurs that a valuable bull becomes vicious at the age of about 5 years, just about the time

his first daughters are in milk Bulls should always be handled kindly and should never be teased The attendant that handles the bull should never show any fear of the animal He should handle the bull firmly and let him know who is master A bull

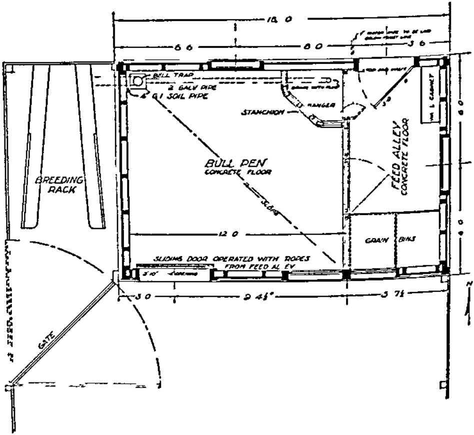

Fig 35 Plan showing the details of a safety bull pen

always seems to know when anyone is afraid of him and will make trouble for one who shows fear

Great care should be taken to make the stalls and fences surrounding the paddock strong and reliable so that the bull will have no opportunity to realize his own power

He should always be led with a staff and if he is very vicious two men should be used to lead him one on each side Each person may use a staff attached to a separate ring in the nose, or one may lead him with a strong staff while the other uses a

rope or strap fastened into the second ring Often, vicious bulls are kept in such a way that they need be handled but very little. A breeding pen can be built in connection with the bull's pen in such a fashion that, with a series of gates, the cows can be bred without handling of the bull This is a very satisfactory way to manage bulls The details of a safety bull pen are shown in Fig 35

Impotency. Many bulls, as they become older, become less certain as breeders and often lose their potency entirely This may be due to several factors The most common are improper feeding and excessive breeding However, little is known concerning this problem If more were known about the feeding of breeding bulls, this trouble would probably be greatly lessened Bulls may be made impotent by improper feeding and then made potent again by proper feeding Care should also be taken that the bulls are not given excessive service, especially when young

Disposal of the Sire When a sire has been used in a herd, he should not be disposed of by sale, slaughter, or otherwise, except perhaps to be loaned out to another breeder, until his daughters have come into milk Many bulls are sold before their real value has been discovered The first heifers do not come into milk until the bull is 4 or 5 years old Usually, the bull has been disposed of before that age is reached, and so, if his daughters prove to be exceptional milkers, it is then too late to get him back If such a bull has been retained he should not be sold as long as he keeps his breeding power After he has passed his service days in one herd he should be transferred to another Many instances are on record in which bulls have been transferred from one herd to another and in each herd have improved the records of the daughters over those of the dams A bull properly handled should easily breed from 9 to 10 years, and many will breed much longer than this, even to 16 or 18 years of age Several methods have been used to retain the bulls until their worth is known After sampling some large breeders put bulls out with other breeders, with an agreement that they may be secured again when needed Others sell bulls with the option of buying them back again at a certain price if desired Others retain them in their own herd with limited use

21

The Principles of Dairy-Cattle Breeding

Although dairy animals have been used since the dawn of history, the study of their breeding is a late development. All breeding up to the time of Robert Bakewell of Deshley Hall, Leicestershire, England, in the middle of the eighteenth century, was without scientific foundation. The early herdsmen may have used selection to a very limited extent, but if so they had no knowledge of the reason for so doing. It was Bakewell who began to improve animals by a method founded upon the principle that "like produces like." By careful selection and by mating animals resembling each other closely in conformation, he was able to fix the type that he desired. By this method it has been possible to establish breeds of livestock that have done more to bring about better animals than any other one factor.

It is true that the ancestry of many of our dairy breeds may be traced back for several hundreds or even thousands of years. Caesar found in Friesland the ancestors of our present Holsteins, even then developed into a very good type of dairy animal. The Brown Swiss and the Simmenthaler have lived for hundreds of years in the mountains of Switzerland. However, up to the time of Bakewell, the introduction of new types into a country was brought about by conquest or by migration, and these, plus geographical isolation, were the chief factors in the development of distinct breeds.

Today, all cattle breeding can be classed under the two heads of breed improvement and herd improvement. The country as a whole, of course, is greatly interested in dairy cattle breed

If the bull proves to be a poor breeder or if he becomes im potent for any reason, he should immediately be disposed of to the butcher

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21

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Today, all cattle breeding can be classed under the two heads of breed improvement and herd improvement The country as a whole, of course, is greatly interested in dairy-cattle breed

improvement, which is a factor of great importance Each individual dairy farmer, however, is chiefly interested in herd improvement If he is able to improve his herd so that he gets a greater return for his labor, it means much to his own welfare Whatever is for permanent herd improvement must in the end react for permanent breed improvement. In fact, all the important breed improvements during the past years have come about largely through the great strides made by some of the master breeders in their own herd improvement.

The early breeders did not fully understand the reason for selection and close breeding but the breeder of today has an explanation of the good results of these practices and an understanding of the factors underlying breeding helps him in his breeding operations

CARRIERS OF HEREDITY

The cell, as previously stated, is the unit of life The body is made up of cells grouped together in a compact mass There are two kinds of cells in the animal body—the body cells and the germ cells The body cells constitute the bulk of the individual. The germ cells are specialized for reproduction and contain the hereditary material that determines the identity of each individual and is known as germ plasm This is the part of the living substances which passes down the line of descent from one generation to another

Each cell contains within its walls a small body known as the nucleus, containing a number of microscopic bodies known as chromosomes These are found in pairs and in a definite number for each species of plant or animal. The dairy cow, for example, has 60 chromosomes, and the human has 48 The chromosomes are considered the bearers of the elements that determine the inheritance of any animal. These elements, or factors, as they are called, which determine the inheritance, appear to be strung along the chromosome in a linear arrangement. Each of the factors is distinct and is transmitted from one generation to another without undergoing any change or becoming contaminated by association with others They do not mix like milk and water, but rather like black and white marbles

Although these factors are distinct units in themselves, many of them are often required to bring out a character. A character, then, is the result of the interaction of many factors plus environment. Milk production and butterfat percentage are *probably dependent on the cumulative effect of a number of* such factors.

THE CELL IN REPRODUCTION

The mature germ cell of the female is called the ovum, or egg, and that of the male is called the sperm. In the formation of mature germ cells the cell divides, and each sperm or egg contains only one-half the normal number of chromosomes.

"About the period of heat of the cow, one or more of the clear vesicles that can be seen in the ovary enlarges and ruptures. There is expelled a tiny colorless ovum or egg which can only be seen with difficulty by the naked eye. This ovum is received within the funnel-like membrane which normally surrounds the ovary, and then passes to the apex of this funnel and then into the narrow duct leading to the horn of the uterus. It is while in this duct that it comes in contact with a large number of male germ cells. A single sperm gains access to the ovum and fusion of the two results. This constitutes the act of fertilization, and the life of a new individual commences at once.

"The ovum carries the complete contribution of hereditary factors which are supplied by the mother while the sperm carries the complete paternal set. The fertilized ovum now commences to divide, and a process of rapid multiplication sets in." *

This leads to the development of a new individual with a new set of characteristics contributed equally by the male and the female.

MENDEL'S LAW

Inheritance is fixed at the time of the fertilization of the egg. It cannot be changed. An individual may fail to reach the full development of the inherited qualities with which he is endowed because of environmental conditions, but he can never exceed his inherited possibilities.

* *Recent Developments in Cattle Breeding*, Finlay

The laws of heredity were first discovered by Johann Gregor Mendel, an Austrian monk, who published the results of his work in 1866 after 8 years of careful experimenting. His paper was not appreciated until 1900, when it was brought to light, and since that time the laws that he discovered have been the general guide for students of genetics Mendel experimented with peas and, by studying the inheritance of simple characters, such as size of pea, vine, or color of flower, was able to formulate the principles of inheritance very much as they are understood at the present time He found that when tall and dwarf varieties were crossed all the progeny of the first generation were tall, hence, tallness is said to be "dominant" over dwarfness, and dwarfness to be "recessive" However, when these hybrid peas of the first generation were planted they produced a mixed progeny, three fourths of which were tall and one fourth dwarf By planting the dwarf peas it was found that they invariably bred true to dwarfness, but the tall variety did not behave in this manner Careful study disclosed that one third of the tall peas bred true to tallness, whereas two-thirds, though tall themselves, bred both tall and dwarf in the proportion of three to one, like the first generation

In the same way, the factors in the animal body segregate at the time of mating For example, if a red cow were bred to a homozygous black bull, all the first generation offspring would be black, hence, black is said to be dominant over red. In the second generation, the offspring would split up in the proportion of three blacks to one red The red would breed true to red when mated with red, and one third of the blacks would breed true to black, but the others would give three blacks to one red, like the first generation This is illustrated in Fig. 36

Figure 36 also illustrates how an animal may be black in color but may carry a factor for red, and when mated with another animal of the same factoral constitution, may give a red calf Such cases though not common in the United States, frequently occur in the Holstein breed Recessive factors may be carried for several generations without external manifestation but when they recombine with other factors of the same kind the character will reappear An animal that is pure for a pair of factors as for example, the animal containing *BB* in the following illus

tration, is described as being homozygous, and an animal that has both members of a pair of factors is described as being heterozygous, as, for example, the animal containing *Bb* in the following illustration

Another character of general observation that is inherited as a simple factor is the presence or absence of horns in cattle

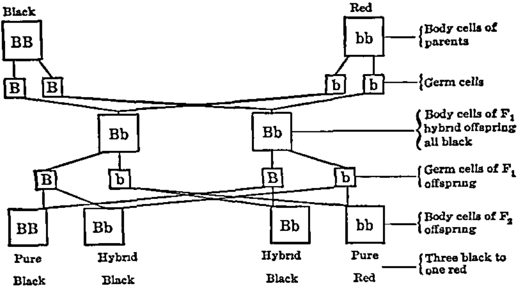

FIG 36 Illustration of Mendel's Law When a pure black animal is mated with a pure red animal, the offspring will be black but will carry the factor for red If these are mated, the resulting offspring will be of the ratio of three blacks to one red

Here, the horned condition is recessive to the polled condition *All horned cattle, therefore, carry the recessive factor in a homozygous condition* A homozygous polled animal mated with a horned animal will always produce polled offspring that are heterozygous Because of this, offspring of polled animals are often horned, they receive a recessive horned factor from each parent

The foregoing examples of Mendelian inheritance are for single unit characters Such inheritance is comparatively simple However, when the two organisms that are crossed differ from each other with respect to two or more different unit characters, the problem becomes more complicated Crosses of the latter type will not be considered in this chapter

INHERITANCE OF MILK PRODUCTION AND BUTTERFAT PERCENTAGE

In the study of dairy cattle, milk production and butterfat percentage are the characters that are the most important economically. Characteristics of economic importance, such as milk production, are quite distinct from characters such as coat color and the presence or absence of horns, in that the former are quantitative and have a continuous distribution in a population of individuals, whereas the latter are qualitative and discontinuous. Because of this, it has been impossible to isolate specific genes which influence milk production, nor has it been possible to determine how many genes are involved. In addition, it must be recognized that environment exerts a great influence on the level of milk production. The facts that are known then are that there are many genes involved in the genetics of milk production and that there is a great amount of variation caused by changing environment.

The problem of breeding for high milk production is one of deciding which animals should be saved for breeding within the herd or when purchasing an animal from outside the herd, to be assured that the animals to be purchased will improve the performance of the herd. Several techniques of a statistical nature have been developed that have increased the efficiency of the application of genetic principles to the problems of animal improvement.

From this work, however, certain fundamental concepts may be presented with certainty. First of all, the selecting for high milk production is subject to tremendous error every time a decision is made about an individual animal. This error is due to the large variation caused by environment, and to the large amount of Mendelian sampling associated with traits that are influenced by many genes. When considering a bull that has several daughters with a very high average production, it must be borne in mind that several factors are involved, one or more of which may have contributed to this high average such as the following: (1) the bull is genetically a better than average bull, (2) the daughters resulted from a better than average

sample of the genes from this bull, (3) the daughters received better-than average environment, and (4) the daughters may be out of genetically superior dams

Just how much each of these factors contributes cannot be known with certainty for a single bull, but it is known that the high daughter average production is partially (and only partially) due to the genetic superiority of the bull

When using pedigree information, distant relations tell less about the inheritance of an individual than do close relatives, such as the parents or full sisters When it is realized that even a large number of records on an individual is not entirely accurate for appraising that individual, it is apparent that to give much consideration to a great grandparent or even to a grandparent may result in a very misleading appraisal of the individual under consideration Only 20 to 30 per cent of the variation among individuals with single milk production records is due to genetic differences, and even with repeated records on the same individual, only about 40 per cent is due to real differences among the individuals When a certain individual is kept for breeding it is because one expects its progeny to be better than those that are culled It is worth noting, however, that even if the parents' genetic constitution for milk production were known accurately (which would be possible if they had an infinite number of records), the genetic merit of the progeny can be estimated only 71 per cent accurately

In summary, when one is breeding for high milk production, several factors must be kept in mind, such as (1) many genes are involved, (2) environment has a large influence, and (3) as a result, a person is subject to a large error

An attempt must be made to take these facts into account when using production records as a basis for selection This is done by regressing the records of the high producer towards the breed average, and in trying to evaluate the environmental conditions under which the records were made

The same generalizations can be made about butterfat percentage as have been made about milk production Butterfat percentage is easier to predict than milk production, since it is not affected so much by environment * A slight negative cor

* *J An Sci*, 6 479 (1947)

relation seems to exist between milk production and butterfat percentage As the milk production goes up, the fat percentage tends to go down, and vice versa However, it is possible to increase both milk production and fat percentage in the same herd *

DETERMINATION OF SEX

Many theories have been advanced concerning the method of controlling the sex of an individual before birth None of these has stood the test of experimentation

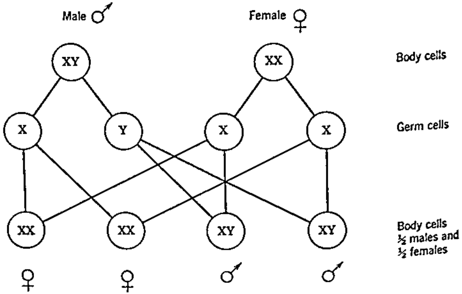

Fig 37 Illustration of sex determination in cattle

There is evidence that sex is determined in cattle and other mammals in the same way genetically as in the fruit fly in which the method of determination was found as far back as 1905 The difference between the sexes involves one pair of chromosomes The sex chromosomes in the female are similar and are usually referred to as *XX* In the male one of the pair is similar to those of the female but the other is different in shape and in the number of genes located on it. The sex chromosomes of the males are usually designated *XY* During reproduction the

* *U S D.A Tech Bul* 349 (1933)

male forms two types of sperms, one of which carries the X and the other the Y chromosome. At fertilization, when the sperm unites with the egg, one-half of the resulting offspring, those in which one X chromosome of the female unites with the Y chromosome of the male will be males, and the other half, those in which one X chromosome of the female unites with the X chromosome of the male, will be females, as shown in Fig 37. There is, therefore, no way of controlling sex It is simply a matter of chance whether the female germ cell will unite with the X or the Y chromosome of the male It often occurs that a breeder obtains a preponderance of one sex or the other in a given year, but this is easily explained as the result of chance. If a sufficient number of animals are considered, the numbers of males and females will usually be about equal

RELATIVE IMPORTANCE OF SIRE AND DAM

The only difference that might be possible between the relative importance of the inheritance from the sire and dam would be caused by sex-linked characters, caused by those genes on one of the sex chromosomes Thus, if the gene were recessive and located on the X chromosome, the character would not appear in the female unless it were present in the homozygous condition. With the male, however, with no allele, the character would appear when a recessive gene was present in the hemizygous condition or when only one recessive gene was present Since there are 30 pairs of chromosomes in dairy cattle, so that only 3 or 4 per cent of the genes would be on the sex chromosomes if they are fairly evenly divided, it would be very difficult to detect the presence of individual genes, and hence research has not disclosed many sex-linked genes

With milk production, which is a sex-limited character, it has been suggested that sex-linked genes are effective A cow's production might resemble her paternal more than her maternal grandam, under similar environmental conditions This is true because she is certain to receive one of her X chromosomes through her sire from his dam Her other X chromosome would of course come through her dam but with equal chance that it would be the one received from the grandsire or grandam.

Evidence to prove that this would have very much effect would be difficult to secure For the bull, there is a perfect transmission of the Y chromosome from the paternal grandsire through the sire, but there is no transmission of an X chromosome from either paternal grandparent One parent may carry a greater number of dominant factors than the other and thus stamp his or her individuality upon the offspring to the exclusion of the less dominant parent However, it must be borne in mind that the offspring of such a mating will be heterozygous, and will carry factors from both parents which may be passed on to its offspring An animal that will pass on its characters to its offspring regardless of how it is mated is called a prepotent animal Such an animal carries the factors for the expression of its characters, which may be either desirable or undesirable, in a homozygous state As noted before, milk production or butterfat percentage is the result of the interaction of several different factors It is, therefore, unusual for an animal to carry all of the factors for the expression of these characters When this does occur, such an animal would be of great value

OTHER CHARACTERS

Although milk production and butterfat percentage are the characters usually considered in the breeding of dairy cattle, other characters should also be considered, as many of them have an economic value Some of the more important of these are type, constitution, longevity, persistency, and fertility These characters are probably inherited by the Mendelian law in the same manner as is the level of milk production.

Type is particularly important to the man who wishes to show his herd Every breeder however, should give it a certain amount of consideration, or the type of his cows may become such that he will have difficulty in selling them Furthermore, a lack of some of the characters that are considered in measuring good body type, such as, for example, a pendulous, poorly attached udder, or poor feet and legs is of great economic importance Cows with pendulous udders are more likely to have mastitis than those with well attached udders and cows with poor feet and legs are not likely to stand up under the strain

of heavy milk production and will probably leave the herd at an early age

Some animals in a herd lack persistency in production They may start out with great promise but go dry long before they should This seems to be an inherited character

Some families of dairy animals are notably shy breeders This may be an inherited weakness, and of course a very important one No matter what factors for milk production an animal may inherit, she may be an economic loss, if because of failure to breed regularly she stands dry for several months between each lactation Most kinds of sterility, however, are due to disease or management and such animals will not pass this character to their offspring

Other animals may inherit the capacity for high milk production but may not inherit the constitution and longevity to enable them to stand up under the strain of heavy production All such factors should be considered in the breeding of dairy animals

THE FREEMARTIN

At least one kind of sterility in cattle is not due to disease or inheritance When a female calf is born as a twin to a male calf, a sterile female, known as a freemartin, results in approximately 91 per cent of the cases The freemartin is a female in which the reproductive organs have failed to develop properly In consequence, such an animal is not only sterile but also develops certain characteristics of the male The male of such a pair would breed normally

Lillie,[*] after extensive investigation, found that this condition is due to the fact that the choria, or membranes, which surround the individuals are united in such a way that the circulatory system of the two are joined and the blood of one individual circulates through the body of the other The blood of the female does not interfere in any way with the normal development of the male, but the blood of the male circulating in the female seems to inhibit her full sexual development This is thought to be due to a hormone which is secreted by the male

[*] *Science*, 43 611

fetus and carried through the blood, arresting the full development of the female reproductive organs Such females will not breed. Occasionally (about 9 per cent) a female born with a male will breed This is due to the fact that the chona of the two animals remain distinct so that each has its own circulatory system Then the female is not truly a freemartin. Males born with males or females born with females should breed normally These same conditions will prevail among triplets and quadruplets when both sexes are found

A freemartin can be determined at an early age by inserting an ordinary test tube into the vagina of the animal. If it can be inserted the full length the heifer should be fertile, but if it will enter only about half the length of the test tube, the heifer is probably a freemartin and will not breed

TYPES OF BREEDING

Three types of breeding are in common use in this country These are (1) breeding of grade herds, (2) breeding of purebreds, and (3) crossbreeding. The first of these is the one generally practiced by dairymen in the United States, the second one is important to those who are developing purebred herds, and the third is as yet practiced but little by the breeders of this country although interest in it is increasing, especially in view of the results of recent experiments

Breeding Grade Herds Approximately 95 per cent of the dairy cows in the United States are grade animals Some of these are low grade, having little blood of any recognized dairy breed, whereas others are of such high grade that they look like purebreds Between these two extremes are being developed many that resemble the purebred in varying degrees

It does not take many generations, starting from scrub or common stock, to develop a good milking herd If a succession of purebred sires is used the inheritance of the first generation will be one half, the second generation three-quarters the third generation seven eighths, and the fourth generation fifteen sixteenths purebred Even in the third generation most of the characteristics are the same as the purebred, and it would be difficult to tell by the appearance whether or not it was purebred.

If good sires are used the production should also be very satisfactory

At the Iowa Experiment Station, thirteen scrub cows were mated to purebred sires of the Holstein, Guernsey, and Jersey breeds The scrub cows were handled and tested the same as the rest of the herd and averaged 3991 pounds of milk and 187 pounds of butterfat (74 lactations) Thirteen daughters of these cows by purebred sires representing the three breeds averaged 5556 pounds of milk and 253 pounds of butterfat (40 lactations). Five cows of the second generation by purebred bulls, granddaughters of the scrub cows, produced 8402 pounds of milk and 358 pounds of butterfat (6 lactations) The daughters of the scrub cows by purebred sires increased 64 per cent in milk and 52 per cent in butterfat over their scrub dams, and the granddaughters increased 130 per cent in milk and 109 per cent in butterfat over the original scrub cows Of course, this increase would not continue in every succeeding generation Greater care in the selection of sires must be exercised when the production reaches or surpasses the breed average

A somewhat similar experiment was conducted at the South Dakota Station The average production of the three original cows was 4155 pounds of milk and 170 pounds of butterfat (20 lactations) Nine daughters of these from the purebred Holstein, Guernsey, and Jersey bulls produced on the average 6707 pounds of milk and 260 pounds of butterfat (28 lactations), and seven granddaughters produced an average of 6260 pounds of milk and 267 pounds of butterfat (7 lactations)

It can be seen that the second generation in this cross was not as good producers as the second cross in the first experiment This was attributed to the sires used, and largely to one sire which failed to maintain even the production of their dams However, the improvement in type, color markings, and other breed characteristics occurred in each succeeding generation and the third and later generation animals could not be distinguished from purebreds

Such experiments show in a very striking manner what can be expected by the use of a purebred bull on grade animals Many high producing and profitable herds have been produced in this

way They can never be registered as purebred animals, but for the production of milk they may be just as profitable as a pure bred herd Of course, purebreds are necessary to furnish the seed stock for the grade herds

Breeding Purebred Herds The breeders of purebred dairy cattle are not in full agreement as to the system of breeding that will give the best results The object of breeding is to fix the hereditary qualities which animals have in their genetic make up, so that these characteristics will be passed on consistently to their offspring Three different methods of breeding, namely inbreeding, line breeding and outcrossing, are used in the breed ing of purebred dairy animals

INBREEDING Inbreeding may be defined as the breeding of very close relatives, as son to dam, sire to daughters, or brother to sister It is one method of fixing characters, whether good, bad, or indifferent Two related parents should have a more nearly similar hereditary make up than two unrelated parents The offspring, therefore, should more closely resemble the parents In other words, if the characters become homozygous and if they are desirable characters, the resulting animal will be a desirable one However, if they carry factors that are not so desirable, the resulting animal will become homozygous for such factors also It is seldom that an animal has all the desirable characters, therefore, when inbreeding is practiced, some unde sirable characters may be concentrated along with the desirable For example, in dairy cattle the character for high milk pro- duction might become homozygous and at the same time the character for low fertility or for poor constitution might become homozygous Thus while a desirable character is being fixed, others that rob it of its usefulness may also be fixed Inbreed ing should not be used, therefore, without rigid selection Most of the experiments have shown that although inbreeding does increase milk production and often improves the type of the animal, yet it is, as a rule, accompanied by reduced vigor and a decrease in birth weight, rate of growth and size at maturity There were more deformities among the calves and the fertility was lower The California Station lists ten defects that ap- peared in the offspring of inbred animals namely, (1) partially

skinless condition (lethal), (2) bulldog calves (usually lethal), (3) dwarfism (not showing until calf was 12 months of age), (4) congenital cataract, (5) flexed pastern, (6) a form of spasm, (7) cross eyed condition, (8) female sterility, (9) malformation of hoofs, with toes wide apart, and (10) short legs However, about three fourths of the bulls used produced daughters that increased the production over the cows with which they were mated This increase may have been in part due to improved environmental conditions

A breeder must keep in mind that inbreeding concentrates the undesirable characters in the same manner and as rapidly as it does the desirable characters Since most animals have some weakness that should not be concentrated, it is usually unwise for the ordinary breeder to practice inbreeding It should be practiced only by the most experienced and skillful breeders

Line Breeding Line breeding is the breeding of animals more or less closely related, but not so closely as in inbreeding Line breeding is a popular method and is a moderate form of in breeding, possessing its advantages and disadvantages to a lesser degree It promotes uniformity in the characteristics but brings in more hereditary influence from unrelated animals, hence, homozygosity is not reached so quickly as with inbreeding But, although desirable characteristics are not developed so quickly, neither do the harmful ones appear so readily Line breeding is a slower method than inbreeding for the fixation of hereditary qualities but one which most breeders prefer as it decreases the dangers associated with inbreeding Usually, line breeding is used to concentrate the inheritance of an outstanding cow or bull An animal is described as being line bred to a certain ancestor

Outcrossing Outcrossing is the system of mating in which animals of different strains, or blood lines, are mated It is quite evident that the animals resulting from such a mating will be heterozygous for every single factor in which the two strains differ completely If, however, the same general type has been fixed in two unrelated families, there is no reason why the cross ing of these two families should result in offspring having a great variation in type Of course, where families of distinctly different

types are mated, a variation in type in the offspring is to be expected

"If sire *A* is homozygous for dominant factors determining high production and his heterozygous daughters are bred back to him, half of his inbred offspring will be homozygous and half heterozygous What will result if *A*'s daughters are mated to sire *B* who is also homozygous for dominant factors determining high producing capacity but is not related to sire *A*? If sire *B* has the same combination of factors that enable him to sire high producing daughters as has sire *A* there is no reason why the results should not be the same as when sire *A*'s daughters are mated back to him" *

Although it is not known definitely that the same combination of factors enables each of them to get the same desirable results, yet the indications from many studies are that the factors controlling high producing capacity are alike in most prepotent sires of the same breed The advantage of inbreeding or line breeding in the fixation of desirable hereditary qualities, such as milk production, is that the characters of the sires or dams definitely known to be great breeders can be concentrated. Ancestors that might be poor are eliminated to the extent of the duplication. In outcrossing, the hereditary qualities of more animals must be known than in inbreeding, but if two animals are known to have the combination of factors for high production, good results may be expected from outcrossing If, however, the hereditary qualities of the animals are not known, it may be unwise to use this method

Outcrossing tends to bring in characters for high production and for types that are not present in the original stock. Such breeding is less likely to produce distinctly undesirable animals as is other methods Usually, however, the type will not be as uniform The United States Department of Agriculture Dairy Division † found that a slightly higher production was obtained from outcrossed daughters than from line bred daughters under the conditions of their experiment. This is shown in the following.

* *Proc World's Dairy Congress* 2 1381.
† *Ann Rept Dairy Division* (1951)

56 outbred daughters produced	20,935 pounds milk	3 75 per cent	785 pounds fat
56 line bred daughters produced	19,299 pounds milk	3 65 per cent	711 pounds fat
The difference was	1,636 pounds milk	0 10 per cent	74 pounds fat

in favor of the outbred daughters (records are 3×-365 day M E)

Crossbreeding. Crossbreeding is the mating of purebred animals belonging to two different breeds In the past it has been practiced intermittently by many dairymen, who followed the method of changing the breed of the sire used on a grade dairy herd Many uninformed dairymen believed that it would be possible to combine the good qualities of one breed with the good qualities of another, especially that of high milk production and high butterfat percentage They believed that a cross of a Holstein with a Jersey was likely to result in the high milk production of the Holstein and the high butterfat of the Jersey Rarely were their hopes realized More often they got an animal with milk production and a fat test in between that of the parents, and little or no gain was made

In 1911, Bowlker, of Massachusetts, mated Guernseys and Holsteins, reciprocally, in order to get the milk production of the Holstein and the butterfat test of the Guernsey This herd was later (1919) turned over to the University of Illinois, but the result in terms of F C M (4 per cent) was that the production of the crossbred heifers was approximately midway between those of the parental breeds This was also true of butterfat percentage, size, and conformation

The most extensive experiment to date in crossing dairy breeds is being made by the Bureau of Dairy Industry at its Beltsville Station This was started in 1939 and involves the use of Jerseys, Guernseys, Holsteins, and Red Danes Although not all the conditions of an ideal experiment were met in this experiment, there were indications that crossbreeding may result in increased production There appears to be an indication of some heterosis (hybrid vigor) effect Of course, this must be studied further before a definite statement can be made If, however, as a result of further study, heterosis is found to result from crossbreeding, crossbreeding may become a progressive and

valuable system of breeding. The artificial breeding associations would lend themselves to its use in a way that would have been impossible with natural breeding.

The results * of the study at Beltsville are given in the following table.

TABLE LXII

PRODUCTION OF FOUNDATION AND CROSSBRED COWS, BUREAU OF DAIRY INDUSTRY

(3X-365 Day Records)

Cows	Average Age	Pounds Milk	Per Cent Fat	Pounds Fat
Foundation	2 yr 4 mo	10,138	4.36	442
54 crossbreds	2 yr 2 mo	13,006	4.50	585
Increase of crossbred over foundation		2,868	0.14	143
81 3 and 4 breed cows	2 yr 1 mo	13,296	4.45	592
Increase of 3—4 breed over 2 breed		290	−0.05	7

After they had been tested for production, many of the two-breed and three-breed cows were put out with farmers and handled under ordinary farm conditions, and they showed continued high production and persistency.

It would seem unwise, even with these seemingly favorable results, for a dairy-cattle breeder to attempt to change his breeding operations to the use of crossbreeding until more is known about the future of such a system. It would seem likely that greater improvement would result by intelligent breeding for type and production within one of the present highly developed breeds.

One type of crossbreeding that has gained considerable favor in the United States, especially with the beef breeds, is the crossing of Zebu or Brahman cattle with native beef or dairy breeds. These cattle are resistant to tick-borne disease and thrive better under hot weather conditions than do the cattle of European origin and hence are becoming popular in the high temperature sections of the United States. The Red Sindhi breed, a milk-producing strain of Zebu, is giving promise of good results when crossed with our native dairy breeds. Many generations of

* *U.S.D.A. Bur. Dairy Ind. Rept.* (1951).

breeding must be produced, however, before a new breed of animals that will combine and transmit all the qualities desired, together with high milk production, will be developed.

NORMAL PERIOD OF GESTATION

For many years the normal gestation period for the dairy cow has been put at 283 days. Many have noted variations from this average and have questioned whether the 283-day period was an accurate average.

The Ohio Experiment Station * has studied the length of gestation of various breeds, based on the more complete and recent data available. It has been known that the Brown Swiss has a considerably longer gestation period than some of the other breeds, but it was not so well known that the Ayrshires, Holsteins, and Jerseys have a slightly shorter gestation period. The following gives the gestation period by breeds, as found in this experiment.

	Days
Ayrshire	278
Brown Swiss	288
Guernsey	283
Holstein-Friesian	279
Jersey	278

They also found that the gestation period of first calf heifers is about 2 days less than older cows of the respective breeds. The Ohio Experiment Station † found also that the male requires about 1 day longer than the female. Table *I* in the appendix gives a gestation table for the different breeds of dairy cattle.

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22

The Selection of a Sire

The Importance of the Sire. The characteristics of the animals in a herd of dairy cattle represent the inheritance that they have received from all their ancestors. On the average, one-half the characteristics of the individual come from the male parent and his ancestors and the other half from the female parent and her ancestors. Since in most herds only one bull is used, and he is mated with all the cows, one-half of all the inheritance of the heifers that are raised comes from the sire. This has resulted in the well known and popular statements that the sire is "half of the herd." Sires that are homozygous for certain characters are able to stamp their characteristics for good or bad on all of their offspring, thus appearing to transmit more than one-half of the inheritance. If these characters are desirable, the bull would be a good one to use, but if they are undesirable, he would be a poor bull to use.

Since the sire supplies one half the inheritance of each animal born, the greatest opportunity for improvement of a herd lies in the introduction of desirable characters through the sire. A good cow has but small influence upon the herd, since the number of offspring which she can produce is limited as compared to the number of offspring of a bull. The necessity of selecting a good sire to head the herd is therefore evident. With natural breeding a bull may be bred to from thirty to fifty cows per year, and in artificial breeding the semen from one bull can be used to breed several thousand animals per year.

Methods of Selecting the Sire. Selection of the sire is one of the most important tasks that the dairyman has to perform. The bull that is chosen today will determine to a large extent the

kind of cows that will be in the milking herd 3 or 4 years hence and for several years thereafter

The sire should be a purebred of the breed selected Pure breds should have the factors for milk production concentrated to a much higher degree than grades or scrubs, since they have been bred with that factor in mind for a great number of years That the sire is a purebred is perhaps all that need be considered in low producing grade or scrub herds where the grading up has just begun, but in high producing grade herds and in purebred herds, much more must be looked for in the sire than the mere fact that he is a purebred He must be one that will increase, or at least maintain the production of the present herd

Several methods are used by dairymen in selecting a sire These methods are either used alone or in combination They are (1) selecting by type or general appearance, (2) selecting by the production of the daughters (proved sires), and (3) selecting by pedigree

Selecting by Type and General Appearance. Many sires are selected simply on their type This method can be used to advantage in the beef breeds, since they show by their conformation the qualities for beef production, the object for which they have been bred The dairy sire, however bred for milk production does not show his milk producing qualities He may show to a certain extent some of the body characteristics that he will transmit to his daughters Some genetic correlation, estimated to be about 0 18,* exists between production and type When a person is selecting for production and production records are not available type conformation is of some value

Breeders who are essentially interested in type conformation should select on the basis of type If they are interested in both type and production they should use both type and production records and attempt to use them according to their economic value as determined by the objectives of the breeder Breeders interested primarily in the production of milk should not place too much emphasis on type ratings Improvement in production by selecting by type is only about one-sixth as rapid as that obtained by selecting by production †

* *J Dairy Sci.* 35 199

† *J Dairy Sci* 35 199

Some important characteristics, moreover, that contribute to the type and value of dairy cows are not revealed in the conformation of the bull Such things as the mammary system, persistency of production, length of life, breeding efficiency, or even milk and butterfat yield cannot be seen by outward appearance

A person may be disappointed when purchasing a bull by this method Although a small positive relationship obtains between type and production, it would not be wise for one to expect to make great improvement in production of his herd by selecting for type alone nor should great improvement in type be expected when selecting for production alone Both must be given consideration in improving a herd

Selecting by Production of Daughters (Using Proved Sires) A proved sire is one with five or more unselected daughters whose production and/or type can be compared with that of their dams This definition of a proved sire may vary somewhat with different breed associations but on the whole they differ but little, one from the other, except in the number of daughters required A proved sire, according to this definition, is not necessarily a good sire His daughters may have better production than their dams, or they may have poorer production than their dams, or they may show little difference in production from their dams

The production proof of a bull is usually tabulated in a manner which shows the number of his daughters that are compared to their dams, the average milk and butterfat production of the daughters and of the dams, as follows

11 daughters average	15 640 milk	597 fat
11 dams average	14,470 milk	528 fat
Difference	+1,170 milk	+69 fat

In this proof the average of daughters exceeds the average of the dams in both milk and fat production

Sire Indexes In order to have the breeding worth of a sire put in terms of pounds of milk and butterfat, workers in the field of dairy cattle breeding have developed sire indexes, which are supposed to be an amount that will express the transmitting ability of a sire Several indexes have been developed, three of these are more commonly used than the others

1. The Equal Parent Index. This index is calculated on the basis that the daughters' production is halfway between that of the sire (if he could express it) and the dam The formula for the equal parent index is E P Index = Daughters' record + (Daughters' records − Dams' records) By using the milk-production figures in the above bull proof, we have the index for milk as follows E P Index = 15,640 + (15,640 − 14,470) = 16,810 The index for butterfat production may be calculated in like manner The Holstein Friesian Association previously used this index

2 The Regression Index In a study of records, Rice found that when a group of cows rises above or falls below the breed average, their daughters will rise or fall above or below the breed average only about one half as far as their dams There appears to be a tendency to regress toward the breed average The regression index is calculated by averaging the equal parent index and the breed average The formula is

$$\text{Regression index} = \frac{\text{E P Index} + \text{Breed average}}{2}$$

By assuming a breed average of 11,550 pounds of milk and 410 pounds of butterfat and using the equal parent index above, we have the index for milk as follows

$$\text{Regression index} = \frac{16{,}810 + 11{,}550}{2} = 14{,}180$$

Similarly, the index for butterfat may be calculated The Ayrshire Breeders Association is using this index

3 The Daughters' Average Index This index is calculated by simply averaging the production of all the daughters of a sire This index does not take into consideration the production of the dams of the daughters It does often allow for a greater number of daughters to be included This index will show just about what can be expected of future daughters of the bull from similar dams This average is used by the American Jersey Cattle Club for their Tested Sire program

Factors to Consider in Selecting a Proved Sire. Several factors must be considered when examining the proof of a sire It is important that all conditions be standardized as much as pos

sible if comparisons between dams and daughters are to be made Some considerations in the selection of a proved sire are the following

1. Standardization of Records. It is necessary when comparing records of one cow with those of another that the records be standardized to a uniform basis, including the age of animals, length of records, the number of times milked per day, etc Unless the records are standardized there is little basis for comparison Usually, the records are standardized to a mature equivalent of a 305 day lactation, made on twice a day milking (M E 305 *d* 2× record)

Mature Equivalent A cow is considered mature when she is from 5 to 7 years of age, depending on the breed Records begun by cows at ages younger or older than this are increased by certain percentages These percentages are known as age-conversion factors These vary some by breeds, because some of the breeds mature more slowly than others The age conversion factors in Table LXIII have been developed from the records of the cows in Dairy Herd Improvement Associations The breed associations have slightly different factors, which are given in Chapter 27

Times Milked per Day When cows are milked more than twice daily, the records are reduced to a twice a day basis by using certain factors The Jersey Club uses the factors 0 833 and 0 741, and the Holstein Friesian Association the factors 0 80 and 0 66 to reduce records to twice a day milking from those made on 3 times and 4 times milking, respectively The Dairy Herd Improvement Association reductions are based on the 3 times per day records, being 20 per cent greater and the 4 times per day records being 35 per cent greater than the twice per day milkings

365 Day Record to 305 Day Record The Jersey Club considers a 305 day record 87 per cent of a 365 day, whereas the Holstein Friesian Association uses 90 per cent of the 365 day production

Although these equalized records take out many of the inequalities between records, the corrections are not as accurate for individual cows as for a group of cows Many factors and

TABLE LXIII

Age-Conversion Factors

(Bureau of Dairy Industry, U S D A.)

Age at Freshening	Brown Swiss, Milking Shorthorn	Ayrshire, Guernsey, Jersey	Holstein	Mixed
1–6	1 718	1 343	1 515	1 429
1–9	1 628	1 301	1 446	1 373
2–0	1 538	1 262	1 377	1 319
2–3	1 469	1 228	1 326	1 271
2–6	1 400	1 195	1 275	1 232
2–9	1 343	1 168	1 239	1 202
3–0	1 286	1 141	1 203	1 172
3–3	1 241	1 120	1 167	1 142
3–6	1 196	1 099	1 131	1 115
3–9	1 166	1 081	1 104	1 091
4–0	1 136	1 063	1 077	1 070
4–3	1 112	1 049	1 056	1 052
4–6	1 088	1 037	1 035	1 036
4–9	1 070	1 028	1 026	1 027
5–0	1 052	1 020	1 017	1 018
5–3	1 040	1 014	1 011	1 012
5–6	1 028	1 008	1 006	1 006
5–9	1 019	1 003	1 003	1 003
6–0	1 012	1 000	1 000	1 000
7–0	1 000	1 000	1 006	1 000
8–0	1 000	1 012	1 018	1 015
9–0	1 006	1 024	1 054	1 039
10–0	1 030	1 047	1 090	1 068
11–0	1 072	1 082	1 138	1 110
12–0	1 114	1 112	1 192	1 152
13–0	1 144	1 136	1 252	1 194
14–0	1 168	1 160	1 306	1 233
15–0	1 180	1 184	1 348	1 266
16–0	1 192	1 199	1 378	1 288

influences are difficult to correct, yet they have a bearing on the size of the records

Other Influences on Size of Records Factors sometimes called management or environmental have an influence on the size of a record and should be taken into consideration when comparing the production of different animals Some of these factors have been listed by Heizer and Bayley * and include (1) length of

* *J Dairy Sci*, 33 376 (1950), 35 540 (1952)

last dry period, (2) condition of dry cow or springing heifer, (3) number of days carrying calf while making record, (4) pounds of T D N fed per 1000 pounds of body weight, (5) nutritive ratio of ration, (6) the amount of selection practiced, (7) the size of the herd, and (8) the month of freshening

Although it is practically impossible to compute such factors into the proof data of a sire, yet it is important that they be given consideration It is known that a cow in well-managed herds may often produce as much as 100 pounds of butterfat or perhaps even more than the same cow would in an average herd This is merely the result of some of the above environmental or management conditions as found in different herds and practiced by different herdsmen

Sires that are proved in a herd where the records of his daughters and their dams were made under uniform conditions of feeding and management should show the true breeding worth of the bull Of course, it may be difficult to evaluate the different environmental conditions but one should at least know whether the conditions were better or poorer than those on his own farm

How feeding and management may affect the bull's proof is shown in the following survey of one bull used in four different herds from which four different equal parent indexes were calculated These were as follows 321, 362, 373, and 481 pounds of butterfat, and there was an explanation for each which had nothing to do with the theory of "nicking"

Herd 1 Equal parent index, 329 pounds of butterfat The daughters averaged 385 pounds of butterfat and their dams averaged 441 pounds of butterfat The history of this herd showed that when the dams were being tested the management was quite good, but before the heifers were tested the herdsman had left and the management and feeding practices were not so good as formerly, resulting in lower production of the daughters and the low equal parent index

Herd 2 Equal parent index, 362 pounds of butterfat The daughters averaged 351 pounds of butterfat and their dams averaged 340 pounds In this herd all the heifers were tested and the conditions were about the same when the dams and their daughters were tested

Herd 3 Equal parent index, 373 pounds of butterfat The daughters averaged 386 pounds of butterfat and their dams averaged 399 pounds The conditions were a little better than those of Herd 2 and all the heifers were tested and the conditions were about the same for both dams and daughters

Herd 4 Equal parent index, 481 pounds of butterfat The daughters averaged 444 pounds of butterfat and their dams 407 pounds This herd had excellent conditions both when the daughters and their dams were tested However, only the promising heifers were put on test The others were removed from the herd for various reasons before testing was begun This resulted in a selected group of heifers being compared to the average run of dams

It is difficult to secure this type of information on many farms but it illustrates the fact that the feeding and management of the daughters and dams should be kept as uniform as possible and that all the daughters must be tested if a true comparison of records is to be made This study did indicate that the theory of nicking is not alone responsible for the varying results obtained from the use of any particular proved sire used in more than one herd

2 Number of Daughters to Prove a Sire Authorities differ considerably in their opinion as to the number of daughters needed to prove a sire Since the value of any proved sire depends upon his actual proof and his age, both these factors should be considered If extreme accuracy in his proof is insisted upon, some of the bull s usable lifetime will be sacrificed A study was made at the West Virginia Station,* in which Ayrshire sires were grouped according to number of tested daughters There were one hundred and fifty four sires with fifteen or more daughters, one hundred and forty-one with sixteen or more, one hundred and thirty two with seventeen or more, one hundred and twenty four with eighteen or more, one hundred and fourteen with nineteen or more, and one hundred and three with twenty or more These daughters were divided into groups of the first five and the next ten daughters, the first six and the next ten, up to the first ten and the next ten, and their production studied

* W Va *Bul* 339

The results indicated that the first five unselected daughters were about as reliable as larger numbers in estimating what the next ten daughters will produce. The small amount of increased accuracy gained by waiting for more daughters was unwarranted, since the full use of the sire would usually be delayed while waiting for more records.

3. Use Only Unselected Records. In the proving of a bull only unselected records should be used. As soon as the matter of selected records enters the picture, the value of production information and the possibility of measuring transmitting ability are severely curtailed and the results biased. As far as breeding programs are concerned, production testing is of value only in indicating the ability of any particular animal to transmit to his or her offspring the capacity to produce milk and butterfat. Every record of a cow should be used in analyzing her production. Selected information, such as the highest record for each animal, should not be used, because it is the record made during which the individual had the most favorable environment and consequently will be misleading. If, for example, a cow is 7 or 8 years old and only one record is cited, this might indicate that this record is selected. Her other records should be obtained before it is of much value in estimating her true worth.

4. Compare the Total Number of Daughters of Producing Age with the Number of Tested Daughters. In appraising the proof of a sire one should find out how many of his daughters of producing age have been registered and compare this list with his tested daughters. If there is a large difference in these figures, one should make sure that there is a logical explanation why some of the animals were not tested. Otherwise, the conclusion would be drawn that there may have been some selection and that only the better daughters had been tested. A person should insist on all the records on all the animals old enough to be tested.

5. Uniform Production of Daughters Is Not Necessary. In selection of proved sires, it has been thought that the sire whose daughters' records are uniform was desirable. If one bull's first ten daughters range in production from 375 to 425 pounds of butterfat and another bull's first ten daughters range from 200 to 650 pounds of butterfat, the first is referred to as being relatively homozygous (his daughters are uniform) and the second

bull as being heterozygous (daughters are not uniform) for production Some breeders have believed the homozygous bull is more desirable because of his ability to transmit production that can be counted on within certain narrow limits and because there would be less chance of his siring a low producing daughter Studies * † have shown that no close association exists between the variability of the first ten daughters and that of the second ten In other words, the sire whose daughters' production ranged from 375 to 425 might, with his second ten daughters, show a considerably greater range, whereas the sire whose first daughters had a wide range might have a narrow range in his second ten daughters It would seem that, on the average, searching out and counting on a bull that is supposed to sire daughters with rather uniform production may lead to disappointment Under the present methods of breeding it seems unlikely that there are bulls homozygous for high butterfat production Only when extreme inbreeding has occurred would such animals be expected to appear The apparent homozygosity of some bulls today is mainly caused by chance and may not be a permanent characteristic of the sire

6. Type of the Daughter. The daughters of the proved sire should also have good type if the bull is to be of the greatest value Udders that may be seriously pendulous and legs that may be badly sickled or cow hocked can become real problems in breeding herds of dairy cattle if these characteristics are concentrated through the use of several sires carrying these traits Since nearly every herd has some fault, care should be taken when selecting a sire that this weakness will not be accentuated but will be corrected The type of the first few daughters will usually indicate the type of the next daughters

7. Health of the Bull. In selecting a proved bull it is important that he be checked thoroughly for disease and breeding efficiency The examination should be made by a competent veterinarian and the bull should be declared free of tuberculosis, brucellosis, and trichomoniasis In addition, his breeding record should be good

* W Va *Bul.* 339 (1949)

† *J Dairy Sci*, 28 109 (1945)

8. **Sire Must Be Better than Present Herd.** If a proved sire is to benefit a herd, his daughters must produce more than the average of the herd A proved sire may be a good one to use in one herd and entirely unsatisfactory in another Too much significance should not be put on the plus or minus value of the herd sire, i e , whether he raised or lowered the production of the daughters in comparison with the dams to which he was bred in the herd in which he was used The important thing to consider is not alone whether he was plus or minus but also the production level of the dams to which he was bred For example, a bull *in one herd might show a plus 25 pounds of butterfat* increase when bred to 300 pound dams, and in another herd a bull might show a minus 25 pounds of butterfat when bred to 425 pound dams In this particular instance the minus bull would seem to be the better of the two sires

Disadvantages of Proved Sires Although the use of a well proved sire is the surest means of permanent herd improvement, a dairyman should not purchase an old sire without considering conditions upon which his successful use depends Often, it is better to get service from artificial breeding associations than to attempt to purchase a proved bull Some matters to consider in using a proved sire are the following

1 The herd should be of a size to justify the expenditure of a sum of money large enough to buy a good proved sire Such sires are scarce, and often sell for high prices

2 The farm should be well equipped to handle old bulls Strong fences, safety pens, and breeding chutes are necessary

3 Old bulls should be provided with roomy exercising lots where they can move around and be in the sun as much as possible

4 Many old bulls are slow breeders as compared to young bulls They may be sure breeders but may not give service every time it is needed Under such circumstances it is sometimes necessary to use a young bull for emergency use

Methods of Securing Proved Sires It is not always possible for a breeder to secure a proved bull of the type and production that is desired Many bulls are kept in the herd only a few years and before their proof has been ascertained they have been slaughtered Many bulls are proved every year through the

dairy herd improvement associations and the herd improvement registry of the breed associations Artificial breeding associations have stimulated the demand for such sires It is necessary to try out young sires or there will be no proved sires available

Several methods of developing proved sires with the desired type and production of offspring are now being used by breeders and artificial breeders' cooperatives

1 *Leasing a young bull to a breeder who is testing* For a breeder who wishes to know what the bull will do before he uses him in his own herd, it is often advisable to lease the bull to another dairyman who, for the service, agrees to test the bull's daughters as they freshen Dairymen are often willing to use such bulls, since they are in this way, able to secure the service of a well bred bull without the outlay of any capital The owner of the bull should insist that the bull be well fed and developed If the bull proves satisfactory he can be returned for use by the owner

2 *By breeding a sample and then putting aside* Some of the dairymen with large herds and some of the artificial breeding associations sample a young bull by breeding a few animals to him and then putting him aside until his daughters come into milk The bull can either be kept in the herd or, still better, leased to another breeder If he is leased, the dairyman who leases him need not be testing but he should be a good feeder and develop the bull to the fullest extent. When his daughters come into milk, the desirability of using him further can then be determined

3 *By exchanging bulls with other breeders* This method was formerly used rather extensively by the breeders of small herds and the exchange was often made through a cooperative bull association Many of the bull associations were the forerunners of the artificial breeding associations and will no doubt be completely absorbed by them in a few years

Selecting a Herd Sire by Pedigree. Most of the sires used to head the herds in this country are selected by pedigree or by a combination of pedigree and type This is the only method available for most breeders since there are not sufficient proved sires in the country to supply all the breeders It is believed by some that if a pedigree of a bull is sufficiently complete in every

detail much of the guesswork can be taken out of selecting by pedigree, in fact, this method might be as successful as by selecting a proved sire However, it is unusual to find a pedigree that gives all the information necessary

Some of the factors that should be given consideration in selecting a bull by his pedigree are as follows

1 His sire should be well proved, as discussed earlier in this chapter

2 The dam of the young bull should have good unselected records The average of these records should exceed the herd average by an appreciable amount All the dams records should be considered A study * based on varying numbers of records on cows showed that when one selected record of a cow was considered, she would transmit only about 10 per cent of her indicated superiority over the herd average One unselected record resulted in the transmitting of 25 per cent of her superiority, whereas with five unselected records as a measure, 50 per cent of her superiority over the herd average was transmitted

3 The offspring of the dam are important The records of the daughters of a dam have been considered more important than the dam's own record in estimating her breeding worth Studies * based on thousands of records show that it takes three daughters with unselected records to give information as reliable as *any one unselected record of the dam in predicting her* breeding value This emphasizes the importance of having records on the daughters as well as on the dam herself A proved son of the cow probably would count as much as a daughter in predicting her breeding value

4 Do not go too far back in the pedigree or pay attention to unimportant detail A dairyman may, when selecting young bulls to head their herds put excessive emphasis on ancestors too far back in the pedigree The sire, the dam, the sisters, the half sisters, and the grandparents should be given consideration

5 Good cow families are important In selecting a sire to head the herd it is always wise to select him from a good cow family Of course, many of the things already discussed go to make up a good cow family some of which are

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(*a*) *High yearly production* Obviously, high production is one of the essentials of a good family The production of members of such a family should average considerably higher than the average of the other cows in the herd, and this production should be continued from one generation to another

(*b*) *Regular breeders* The cows in a good cow family will be regular breeders An animal that produces 400 pounds of fat in a 305-day lactation and drops a calf within the year is usually a profitable animal

(*c*) *Resistance to disease* The members of certain families also seem to be more resistant to disease than are others Some of this may be due to udders For example, the Nita family in the West Virginia University herd, which was a fairly large family of high producers, had udders that were well held up to the body, and not one of this family was removed from the herd because of mastitis However, the Anna family, another high producing family, but with large, pendulous type udders, had five of its ten members removed because of mastitis

(*d*) *Long life* Longevity is a good characteristic to have in a cow family From a profit point of view, it pays to have a cow produce over a long period of time It is generally estimated that a cow in her first two lactations merely pays for the cost of raising her to producing age Only in her third lactation and thereafter does she begin to render a profit. The presence of several old cows from one family is a good indication of the desirability of that group

(*e*) *Persistency* A cow that produces at least a moderately good flow of milk up to the time of drying off is known as a persistent cow Contrariwise, a cow may be an extremely heavy milker for the first few months of her lactation and then dry off early She lacks persistency There is a strong indication that this character is an inherited one, and a cow family with persistency should be selected

6 The type of the animals in the pedigree When a bull is selected to head a herd, it is important to know the type of his sire and his sire's daughters as well as the type of his dam and of her daughters The prospective herd sire should have a sire and a dam that do not, themselves, show any major physical weakness, and they should also indicate through their sons and

daughters that they do not transmit any physical deficiencies. The future sire himself should have satisfactory type and be well developed. Experimental results have shown that the heritability of classification ratings for type is only about 0.3, in other words, an offspring inherits about one third of the observed superiority of the parent's type. For example, if a herd average is 82.5 points and the average type rating of the parents is 87.5

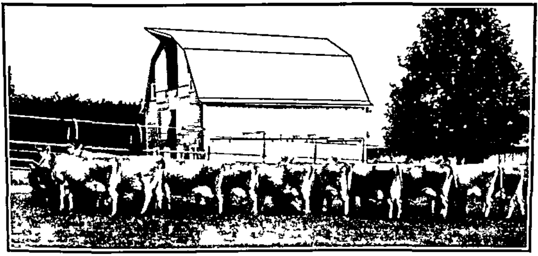

FIG. 38. Ten daughters of Blonde's Famous Lad 368886. This group includes one excellent, six very good, and three good plus cows; one is a ton of gold cow. This bull's seventeen daughters averaged 8122 pounds of milk and 463 pounds of fat (2 x 305 M.E.), and nineteen classified daughters averaged 84.08 on type score. (*V.P.I.*)

points, then the offspring of these parents can be expected to average about 84 points, $82.5 + 0.3\ (87.5 - 82.5)$.

There is also a small relationship between type classification ratings and production. Within herds the study of thousands of Ayrshire records showed that on the average there was an increase of 13 pounds of butterfat for each increase of one grade in the type scale. Dairymen cannot expect to make any satisfactory increase in production in their herds by selecting on the basis of type alone; on the other hand, when selection is made for production alone, little progress will be made in improving the type of the herd. Consideration of both type and production is necessary if the herd is to be improved in these characteristics. The following is an example of a good pedigree of a young bull calf.

A GOOD PEDIGREE

Bull Calf

All Records 305 Days 2× M.E.

Cacapon Lindy 6th, App., Very Good

10 daus. ave. 8960 M., 4.32%, 387 F.
10 dams ave. 8293 M., 4.03%, 334 F.
Equal Parent Index 9627 M., 4.61%, 440 F.
First 7 classified daus. ave. 85.1.

Penshurst Lindy, Approved

80 daus. ave. 8784 M., 4.42%, 388 F.
80 dams ave. 9007 M., 4.13%, 372 F.
Equal Parent Index 8561 M., 4.71%, 404 F.
Ave. classification score of 17 classified daus. 83.1.

Cacapon Jewel by Leto 15th, Excellent

9 recs. ave. 10,558 M., 3.79%, 400 F.
Lifetime production thus far. 100,103 M., 3.81%, 3810 F.
1 dau. with 2 recs. ave. 10,522 M., 448 F. Daughter classified Very Good.

Cacapon Lily by Leto 18th, Very Good

4 recs. ave. 12,569 M., 584 F
1 dau. with 4 recs ave. 9506 M., 433 F Daughter classified Very Good.
1 son with 11 daus that ave 9849 M., 4.17%, 411 F. Son classified Very Good.

Cacapon Leto 18th

23 daus. ave. 8360 M., 4.21%, 352 F.
23 dams ave. 7281 M., 4.24%, 309 F.
Equal Parent Index 9439 M., 4.18%, 395 F.

Cacapon Nita by Caesar, Excellent

7 recs. ave 12,633 M., 562 F. Actual lifetime production 125,326 M., 4.52%, 5661 F. 5 daus have 11 recs. ave. 11,178 M., 500 F. Ave. classification score of daus 85.0.

OTHER FACTORS IN SELECTING A SIRE

Age of Sire. On the basis of only the age factor, a young sire is preferable to an old one He is easier to handle and is often a surer breeder Often, when a sire becomes unruly he is sold to the butcher Some breeders seem to think that an aged sire is more prepotent than a young one, but the science of genetics shows that nothing is added to or taken from the germ cells with advanced age Therefore, unless an aged sire has daughters in milk that are proving to be good producers, or daughters that will soon be tested, there is no advantage in using him In fact, if a sire is to be purchased upon his type and pedigree, a young one should be chosen, because, as a rule, young sires are surer breeders and have a longer period of usefulness ahead of them They are usually less trouble to handle than aged sires

Age of the Dam of the Sire. Many people object to a sire that is the first calf of a heifer, because they believe that he will not be prepotent There is no reason, however, why the first calf of a heifer should not be just as prepotent as the calf of a mature cow The only objection to such a selection is that the heifer has not had the opportunity to show what she inherits in the way of milk production It is often unwise to select such an animal for that reason In selecting a sire that is the calf of an older cow, an opportunity is usually available to ascertain the producing ability of the dam

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23

Establishing a Herd

The best method of starting a herd depends upon such factors as the capital available, the experience of the man starting the business, and the market for the product. In general, the man who has had little experience in the handling of dairy animals or who has a limited amount of capital should start with the animals he has at hand or can readily secure, and, by means of a purebred sire, breed up his herd, but the man who has had dairy experience and has some capital, or the man who has capital but no animals with which to start, may buy sufficient high grade or purebred cattle to make up a herd.

Before a person starts into the dairy business he should decide, first, what breed to begin with, and, second, whether to start with purebreds or grades, or a combination of the two.

Breed to Choose. There are five major dairy breeds in the United States, all of which have proven satisfactory in various parts of the country. The main dairy breeds are the Ayrshire, Brown Swiss, Guernsey, Holstein-Friesian, and Jersey. There are also several minor breeds, and several dual-purpose breeds from which to choose.

AYRSHIRE. The native home of the Ayrshire is in Scotland. They are red and white or brown and white in color and have long, up curving horns. The Ayrshire breed is strong and vigorous and an especially good forager, doing well on pastures where other breeds would suffer from lack of feed. The average mature cow will weigh from 1100 to 1200 pounds, and the bull from 1500 to 2000 pounds. The calves are hardy and weigh about 75 pounds at birth. The Ayrshire has the best udder of the dairy breeds, it is well attached forward and back with no tendency to be pendulous. The quarters are even, and the teats medium in size and well placed. The Ayrshire makes good beef,

since the dry cows fatten readily The cows seem to lack persistency in milk production as compared to other breeds

Ayrshire milk contains about 4 per cent butterfat Ayrshire cows in herd improvement registry in 1950 averaged 9544 pounds of milk, testing 4 07 per cent and containing 389 pounds of butterfat They are found in largest numbers in the northeast, but some are found in practically all the states

BROWN SWISS The original home of the Brown Swiss breed was in Switzerland, only a few have been imported to the United States and none since 1906 They are brown in color, varying from a silver to a dark brown The nose and tongue are black, with a light colored band around the muzzle The breed is strong and vigorous A mature cow should weigh from 1300 pounds to 1500 pounds and the bull from 1800 to 2100 pounds The calves are large and strong, weighing about 95 pounds at birth The Brown Swiss are sturdy in appearance, with well developed brisket and dewlap and the body well covered with flesh

Under herd improvement test the Brown Swiss breed had an average on all records made in 1950 of 9915 pounds of milk and 402 pounds of butterfat, with a test of 4 0 per cent The Brown Swiss are found in nearly all of the states but in greatest numbers in the upper midwest and northeastern states

GUERNSEY The Guernsey breed originated on Guernsey Island, one of the Channel Islands, near the coast of France In color, the Guernsey is fawn with white markings clearly defined A brindle color or a smoky or black muzzle is not in favor The average Guernsey cow will weigh about 1100 pounds and a mature bull about 1700 pounds Calves weigh about 70 pounds at birth and are more difficult to raise than some of the other breeds

The milk of the Guernsey is high in butterfat (average about 4 9 per cent) and carries a deep yellow color The Guernsey is angular and her flesh is yellow in color and is not looked on with favor as beef The breed under herd improvement test in 1950 averaged 8142 pounds of milk and 396 pounds of butterfat with an average test of 4 8 per cent. They are found more in the north central, northeastern, and Atlantic Coast states, although some are found in all the states

HOLSTEIN-FRIESIAN The Holstein-Friesian breed of dairy cows originated in the northern part of the Netherlands, especially in the province of Friesland and the neighboring provinces of northern Germany They are black and white in color, with the markings clearly defined The mature cow should weigh from 1400 to 1600 pounds and a mature bull should weigh not less than 2000 pounds Calves average about 90 pounds at birth and are strong and vigorous

The Holstein Friesian gives more milk than any of the other breeds and the milk is lower in butterfat than the other breeds In the herd improvement registry in 1950 the average production for the breed was 11,616 pounds of milk and 418 pounds of butterfat, with an average test of 3 6 per cent They are found in greater numbers in the northcentral and northeastern states, although some are found in all the states

JERSEY The Jersey breed originated on the Island of Jersey, one of the group of Channel Islands located between England and France They are fawn in color, with or without white markings They are the smallest of the major breeds, the mature cow weighing from 900 to 1000 pounds and the mature bull from 1500 to 1600 pounds The calves average from 50 to 60 pounds at birth The breed matures earlier than the other breeds and often are sufficiently mature to calve the first time at 24 months of age Because of their size and the yellow color of their meat they are not looked on with favor for beef

The Jersey breed produces less milk but has a higher test than any of the other breeds Under herd improvement tests Jerseys in 1950 averaged 7249 pounds of milk and 387 pounds of butterfat, with an average test of 5 36 per cent This breed is found in all parts of the country and is strong in the South, where they seem to stand the heat better than some of the other breeds

Several minor breeds are found in small numbers in the United States These include the Red Dane, the Dutch Belted, and the Devon There are also several dual purpose breeds, the principal ones being the Milking Shorthorn and the Red Polled

Considerations in Selecting a Breed In selecting a breed several factors are to be considered, namely, (1) the form in which the product is to be marketed, (2) the breed of cattle

most common in the community, (3) the characteristics of the breed as to production, initial cost, health, breeding ability, longevity, and economy, (4) the adaptability of the breed to weather and pasture conditions and topography of land, and (5) the preference of the breeder

THE FORM IN WHICH PRODUCT IS TO BE MARKETED If the dairy man is selling his milk on the wholesale market, he would probably be ahead if he had a breed which gave a large amount of milk unless the market would pay enough more for high fat milk to justify the extra cost of its production When milk is desired, the Holstein, the Brown Swiss, or the Ayrshire should be given consideration on account of their large and economical milk production In areas where butterfat or cream is sold, or where special prices can be received for high testing milk, the Channel Island breeds should be given consideration These breeds will produce butterfat at a lower cost than will the lower testing breeds However, other factors may affect the income from the milk. For example, if cream is sold, the value of the skim milk must be considered It has a definite value when fed to calves, pigs, or chickens The market for the product is one of the most important factors in deciding on the breed to use

THE BREED OF CATTLE MOST COMMON IN THE COMMUNITY One of the first considerations for a beginner to keep in mind in starting a herd is the breed that is common in the community It is difficult for an isolated, small breeder to dispose of his surplus stock to advantage If, however, several of his neighbors have the same breed, buyers from other localities may be attracted to these farms because of the better chance of getting the desired animals from one or more of the different breeders Other advantages of breeding together, are the possibility of securing bulls together or of trading bulls from one farm to another; of having sales of surplus stock, and especially of having men in the community with whom to talk and discuss, either individually or in organized breed societies, the breed that has been chosen This is true not only with purebred breeders but with grade breeders as well

THE CHARACTERISTICS OF THE BREED One should select a breed that has the ability to produce well to breed consistently, to live long to produce strong and vigorous calves and to pro-

duce cheaply the product to be sold The breeds vary somewhat in production, although when total fat production per cow is considered there is not a great difference Some breeds seem to be better breeders than others and will stay in the herd for a longer period of time Some are more persistent in milk production The calves of some are large and adapted for veal production, whereas others are small and unprofitable Some of the breeds make good beef when they are sold on the market, others are small and have low beef value, and some will cost more when purchased to start a herd However, the beef value of the animal or the initial cost should not be given too much consideration, since this is a very minor part of the income and over a period of several years makes little difference The amount of milk produced and the economy of its production should be given first consideration

THE ADAPTATION OF THE BREED The adaptation of the breed to the farm on which the herd is being started should be given consideration Certain breeds, notably the Jersey, are adapted to warmer climates than are some of the other breeds When the farm is hilly and the pasture rather poor, the Ayrshire and Brown Swiss are said to be best adapted, whereas the Holstein is adapted to level land where the pasture is lush The larger breeds as a rule will consume more rough feed than will the smaller breeds All these qualities should be considered when selecting a breed

PERSONAL PREFERENCE The individual preference of the man who is about to start a herd should seldom be the deciding factor in the selection of the breed, since a natural stockman will soon learn to like the breed that he has to work with, especially if that breed makes him more money than would another breed If, however, a man has considered all the factors that have been outlined and still is undecided, he should then take the breed of his choice Personal preference must not overshadow the matter of the quality of different breeds and their adaptability to a particular farm

In summing up the question of which breed to choose, it should always be kept in mind that good cows and poor cows are found in every breed and the dairyman who selects good individuals of any breed and gives them good feed and care, and

handles his milk properly will have a good chance of success, regardless of which breed he selects

Grades or Purebreds Only about 5 per cent of the dairy cattle in the United States are purebreds This means that the majority of dairymen are content with grades and that a very large part of the milk produced comes from grade herds Many of the grade herds have been bred up for many generations by the use of purebred sires, so that they are now, to all intents and purposes, nearly as good as most purebreds One generation with a purebred bull makes the cattle half purebred, two generations, three fourths purebred, three generations, seven-eighths purebred, and four generations, fifteen sixteenths purebred Such animals will look like and may be just as productive as purebreds, but they cannot be registered as such Consideration is being given a supplementary registration of grades

When a dairy farmer becomes especially interested he may prefer purebreds to grades Although, as has been shown, the grade herd in time could be developed so that it would be just as profitable as a purebred, as far as milk production is concerned, it is usually desirable for a breeder who is interested in purebred cattle to purchase a few good purebred animals and replace the grades with purebreds as the calves develop Grades receive most of their good qualities from their pure blood

Whether one should select purebreds when starting a herd depends largely upon the breeder himself Will he be willing to test the cows in his herd to eliminate disease, to spend the time necessary to register his animals and to transfer those that he sells, and to do the many other things necessary when purebreds are kept. If he dislikes or will not attend to these details, he had better breed a grade herd But if he is willing to attend to all the details of feeding and management necessary to bring out the full capacity of his herd, he will usually not be satisfied except with a purebred herd

A Standard of Production Before starting a herd, one should establish in his own mind a tentative standard of production. This is necessary, regardless of the breed or whether the herd is grade or purebred This amount must be at or above the lowest limits profitable under the conditions in the community To illustrate it might be that under prevailing prices in the

community, a mature dairy cow, in order to return a profit, would have to produce 7500 pounds of milk or 300 pounds of butterfat in a year In purchasing a herd, those cows that will not produce this amount should not be considered Younger cows are not expected to produce quite so much as the mature ones, but a first calf heifer that will not produce more than 70 per cent of standard should not be purchased One should also have standards for type, for freedom from disease, and for other characteristics

Breeding a Dairy Herd The disadvantage of breeding a herd from a common herd is that the process requires several years However, in a locality where dairying has not been well developed, it is seldom wise for a beginner to take up the breeding of purebred or even high-grade dairy animals until he has had some experience in handling a dairy herd It would probably be wise to take the common cows that are already on his farm, and, by the use of purebred sires, breed up the herd to a profitable level The dairyman should feed his herd a good ration, milk them properly, weigh the milk from each cow, and raise the calves only from the best cows In this way he should be able, with the use of a good sire or with artificial breeding, to develop in several generations a herd of high producing cows By the time that he has developed such a herd, he will have become familiar with dairy methods and can feed and care for his animals properly He will also have time to develop a satisfactory market for his product

Several experiments have shown what can be expected from the use of a good purebred bull on common cows The Iowa Experiment Station purchased and mated scrub cows to purebred bulls The second generation animals produced, on the average, 8402 pounds of milk and 358 pounds of butterfat, which was an increase of 4742 pounds of milk and 186 pounds of butterfat over that of their scrub grandams These second-generation animals were producing almost as much as the average of their breed and their color markings and conformation were very similar to the breed, the blood of which they carried

Buying a Herd One of the advantages of buying a herd instead of breeding one is that it is not necessary to wait a number of years before beginning to make some profit If a man

knows the dairy business and has a ready market for his product, it is a waste of time to start with low producing animals This may be necessary if the person desiring to start in the dairy business lacks sufficient capital to purchase high producing animals He should at least secure a few good animals and build a herd around them as soon as possible.

The disadvantages of buying a herd are (1) it requires considerable capital, (2) it entails danger of disease, and (3) it is difficult to purchase good foundation animals

CAPITAL REQUIRED If a man wishes to purchase good animals, he must pay a good price for them even though they may be grades It is true that many cows can be purchased at around beef prices, but these are mostly culls that another dairyman has not found profitable, or, on account of disease, shy breeding, or for other reasons, wishes to get out of his herd. Good cows that will make a profit in a dairyman's herd are usually high in price and difficult to purchase, since no breeder wants to sell his best animals Some wealthy men who are able to pay any price for an animal have established high-quality herds by purchase, but such are few in number and even they have trouble in securing the best animals, since some of the better animals are not for sale

In assembling a herd by buying three methods are available namely, buying cows, buying heifers, either bred or unbred, and buying calves The choice depends upon time, capital, experience, and other conditions

BUYING COWS. The surest and quickest way to secure a high producing herd is to purchase cows with production records. This method, of course, requires considerable capital at the start. Ordinarily, however it will prove more economical than buying untested animals at a considerably lower price The trouble with selecting cows by their conformation is that the conditions under which the selection is made are often not uniform Some cows are dry and making up for freshening or perhaps have just freshened and are giving a large quantity of milk. These look their best and are usually in demand. Others equally as good and often much better producers, are thin, because of heavy milk production, and are overlooked by the purchaser It is difficult for anyone but an experienced judge to

adjust for the stage of lactation and the condition of the animal, and even the best of judges are sometimes fooled Many cows are purchased by this method, however, since production tested cows are few in number and usually sell for a much higher price than do those without records Good, healthy cows purchased from high producing herds from an honest breeder will usually prove to be profitable

In the purchase of milking animals, careful attention should be given to the age of the animals Cows, on the average, remain in the milking herd for only 4 to 5 years Usually, a cow will reach her maximum production when she is from 5 to 6 years of age and will continue at about the same level until she is 9 or 10 years old, after which she will gradually drop off in production Young cows have more years of usefulness left and are more valuable to the purchaser Cows more than 7 or 8 years old will usually not have many more years of productive life, since the average cow leaves the herd when she is 7 years of age

Buying Heifers One of the most popular methods of starting a herd is the purchase of bred heifers A person who owns or has access to a good bull sometimes prefers to purchase open heifers, but the bred heifer seems to be more popular for the beginner In buying heifers, considerable attention should be given to the kind of cows in the herd This will give an indication of the type of cows and especially the kind of udders to expect Whereas, on the average, the type of the heifer is a fairly good indication of how she will look when mature, there is no way to tell exactly how the udder will develop Sometimes the size and general conformation of a heifer is satisfactory, but when she freshens her udder is quite undesirable It may be small, poorly attached, quartered, or pendulous The purchaser should see that the dams of the heifers have good udders

Buying Calves The way to start a herd with the least capital outlay is to purchase calves In many dairy sections, especially in the market milk areas, high grade calves can be purchased at a fairly low price Purebred calves can also sometimes be secured at a nominal figure The cost of raising calves is highest in the early months when they are fed considerable milk If the buyer has feed for such calves, he may be able to buy them and

raise them for less than the purchase price of mature animals This system requires more time as the calves will not be in production for at least 2 years It is also more difficult to judge the individuality of the young calf than of the heifer or mature cow this is especially true of the udder The general production level and the type of the herd that the calves come from and the sires used are of greatest importance

There are many examples of both grade and purebred herds being established by each of these methods The length of time required and the levels to which the herds have developed differ widely

It is fortunate when an already established herd is continued from father to son More young men with 4 H club and vocational agriculture training and college graduates are returning to their home farm than previously

The Disease Problem One of the important considerations in purchasing a herd is the danger of disease especially such diseases as tuberculosis brucellosis, trichomoniasis and mastitis Even with the development of effective tests for tuberculosis and brucellosis, care must be taken and cattle should be purchased only from herds accredited free from these diseases Even then the animals should be tested at the time of purchase and if they are to be moved in with other cows it is advisable to isolate them for a period of 30 to 60 days and have them retested before being placed in the herd

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Artificial Breeding of Dairy Cattle

The breeding of dairy cattle by artificial insemination is a widely practiced method of breeding. In some herds the cows are bred by this means to sires in the herd, and sometimes the sires in one herd are used to breed cows in other herds. The greatest use of artificial breeding, however, is in the organized artificial breeding associations. During the year 1951, a total of 3,509,573 cows * were bred through these organizations in the United States. More than 4 million cows were enrolled in artificial breeding associations in 1952. This method of breeding dairy cattle has been expanding rapidly and promises to be one of the best methods of improving the dairy herds in this country.

HISTORICAL

The earliest use † of artificial insemination of animals that has been reported was in 1322, when an Arab chief artificially inseminated a mare. In 1782 an Italian used the technique successfully with dogs. Workers in Denmark and Russia ‡ began investigating the possibilities of the practice shortly before 1900. The Russians were the pioneers in its use with cattle. In the decade 1930 to 1940 they made rapid advances in using the technique with horses, cattle, and sheep.

The first cooperative artificial-breeding association was organized in Denmark in 1936. Perry ‡ studied the methods and organizational setup used in Denmark and in 1938 was instru-

* *U.S.D.A., DHIA Letter,* 28:3 (1952)
† *U.S.D.A. Circ* 567 (1940).
‡ *Artificial Insemination of Farm Animals,* Perry, 1952.

mental in organizing the Cooperative Artificial Breeding Association in New Jersey. Although this was the first organization for artificial breeding in this country, the method had already been practiced in several herds and research work was getting under way at several agricultural experiment stations.

ARTIFICIAL BREEDING

Artificial breeding is the process of breeding a female to a male without the incidence of natural mating. The semen is collected from the male by artificial means. The female is inseminated by placing a portion of the semen, either as collected or diluted, into the cervix or uterus by mechanical methods. Artificial breeding has progressed faster with dairy cattle than with any other class of livestock.

Advantages of Artificial Breeding. The advantages of artificial breeding are greatest when used through an organization; however, there are some advantages for it in its use from sires within a herd. There are also limitations to its use within a herd. The following are some advantages of artificial breeding.

1. It makes available sires of proved inheritance for milk and butterfat production to all dairymen within the area served. Previously, only the better dairymen in a county had the use of good sires.
2. The services of superior sires are greatly extended. A bull can be bred to fifty to sixty cows in a year by natural service, but through organized artificial breeding he may be used to breed several thousand cows per year. Also, artificial breeding within the herd increases the number of cows that can be bred to a bull.
3. The dairyman does not need to keep a herd sire, which eliminates the danger that accompanies the handling of a bull.
4. The dairyman does not have the problem of locating and purchasing a new herd sire every 2 years to avoid inbreeding.
5. The cost of breeding cows artificially through an association is less than the cost of purchasing and maintaining a bull of the same quality. This is especially true with the small breeder.

6 There is less danger of spreading reproductive diseases Artificial breeding is often practiced where bulls are kept in the herd because of the possibility of spreading certain diseases with natural services

7 There is less chance of using poor semen The semen of the bulls used artificially is checked regularly and a number of bulls are used, thus decreasing the possibility of using sterile bulls regularly for a period of several weeks before discovering the difficulty

8 Large mature bulls often cannot be used on small heifers naturally

9 Some bulls, because of injury or other reasons, cannot be used naturally but may be used artificially

Limitations of Artificial Breeding There are some limitations to the use of artificial breeding such as the following

1 A well trained technician is necessary An unskilled person or one who is not careful may injure the cow and will usually have low conception rates

2 The equipment must be kept clean and sterilized, and strict sanitation methods must be practiced or diseases may be spread from cow to cow or from one herd to another

3 A dairyman cannot always breed certain cows to the sire that he prefers since a bull is usually used only once per week

4. A definite linebreeding program cannot usually be followed.

5 Fewer bulls are needed, consequently, the sale of bulls from purebred herds is reduced

Sensational Aspects Many sensational reports have been made on the use of artificial breeding For example, semen was collected from a grand champion bull at the Pacific International Livestock Show and shipped by plane to the World's Fair in New York, where it was used to inseminate cows successfully On another occasion, semen collected from a bull in Pennsylvania was flown to Australia, where cows were inseminated and some of them conceived There are also records of semen being taken from a bull immediately after his death and used successfully in impregnating cows

These cases do prove that it is possible to mate animals that are great distances apart, however, it is not usually practical to do so

Growth in the United States

Artificial breeding is now receiving much attention in the research fields. It is responsible for an increased interest in the physiology of reproduction of the cow and the bull

The research now under way includes such things as nutrition of bulls, the methods of collecting semen, the diluting, preserving and storage of semen, methods of shipping semen, methods of inseminating the cow, the time of inseminating with respect to the heat period, factors affecting conception, and methods of selecting sires

The organized breeding associations account for all but a limited amount of artificial breeding The first organization in this country, the New Jersey Association, formed in 1938, had 102 members, who enrolled 1050 cows From this beginning the work grew, and in 1952 there were 94 bull studs * in forty-three states and in Alaska and Puerto Rico furnishing semen to 1648 inseminating units in all forty-eight states and the two territories These units were made up of a total of 543,397 herds This service is reaching small herds, since herds with 15 cows † or more number only about 256,000 During 1950, more than 10 per cent of the milk-cow population were bred artificially. About 11 per cent of the cows bred artificially that year were registered, whereas only about 5 per cent of all milk cows in the country are registered

The 94 bull studs in 1951 had a total of 2187 bulls, which was an average of 25 bulls per stud There were 1605 cows bred per bull in service

The Bull Stud

The great majority of the bull studs are owned cooperatively by dairy farmers Some are operated in cooperation with the agricultural college A few of the studs are privately owned

Job of Bull Stud. The job of the bull stud is to produce, process, and ship regularly, viable bull semen

THE BULLS The majority of the bulls should be proved sires It is desirable and wise also to keep a limited number of care-

* *U S D A, D H I A Letter*, 28 3 (1952)
† *U S D A, D H I A Letter*, 27:3 (1951)

TABLE LXIV

GROWTH OF ARTIFICIAL-BREEDING ASSOCIATION WORK IN UNITED STATES, 1939–52

Year	Associations (Units) number	Enrollment: Herds, number	Enrollment: Cows, number	Cows Bred number	Bulls in Service: Total Bulls, number	Bulls in Service: Proved Bulls: Number	Bulls in Service: Proved Bulls: Per cent	Butterfat Production Level of Daughters of Proved Sires, pounds	Cows Enrolled per Sire 1946 and after Cows Bred per Sire number
1939	7	646	7 539		33				2 8
1940	30	2 971	33 9 7		138				246
1941	4	5 997	0 51		237				99
194	3	12 118	112 88		412				4
1943	99	23 448	18 524		5 4	135	23 1	419	218
1944	95	28 627	218 0 0		657	1 9	19 6	421	33
1945	195	43 998	300 732		29	147	20 2	428	495
1946	336	3 293	5 9 477	537 376	900	209	23 2	4 8	597
1947	608	140 571	1 125 040	1 184 168	1433	335	23 1	430	815
1948	963	224 493	1 43 327	1 713 581	1745	4 6	24 4	433	98
1949	1 63	316 177	2 412 160	2 091 1 5	1940	514	26 5	436	10 8
1950	1460	372 968	2 827 530	2 619 555	2104	559	6 6	444	1245
1951	1653	467 224	4 0 7 06	3 509 5 3	2187	634	29 0	459	1605
1952	1648	543 397			2324				

fully selected young bulls These may be used in the heaviest breeding season when dairymen are most concerned about getting a high conception rate Young bulls often have a higher breeding efficiency than do old bulls It is a common practice during the fall and early winter, which is the heavy breeding season in most areas, to ship semen from both a proved bull and a young bull on the same day This allows a choice for the dairymen

Using young bulls to a limited extent, and then holding them until they are proved, offers one of the very best means of sire replacements

PROVED SIRES Twenty nine per cent of the sires reported in artificial breeding associations in 1952 were proved The average production of the daughters of these proved sires was 459

pounds of butterfat.* Apparently, the breeding associations are successful in securing many of the better proved sires.

Maintaining suitable bulls in sufficient numbers requires a continuous search for bulls. Copeland † reports, from a study of 288 registered bulls, that they became infertile breeders at an average age of 9 years and 6 months. Seven per cent remained

Fig. 39. Bulls housed in an open shed at the Virginia Cooperative Artificial Breeding Association Bull Stud.

serviceable until more than 14 years of age. Since the majority of bulls are not proved until they are 7 years old or more, the life expectancy for further usefulness is not great.

Increasing the effective life span of a sire after he is proved is of great importance. Proving them at a younger age may be the most effective means. Breeding a young bull artificially to a number of cows would be the first step. Getting the heifer calves grown out well and bred at an acceptable early age would be the next step. The third and final one would be to test the daughters after calving and to assemble the records for proof as

* *U.S.D.A., D.H.I.A. Letter*, 28:3 (1952).
† *Jersey Bul.*, p. 871 (1929).

early as they are completed It should be possible to get a program going that will sample and prove bulls before they are 5 years old Preliminary proof may be obtained several months earlier If the preliminary proof appears encouraging the bull can be placed back into service without delay, pending the final information, for continued use

Research on nutrition of young and old bulls, on exercise (forced and natural), on collection management, and other factors is aiding in extending the service life span Further information such as greater dilutions and freezing semen, will no doubt give greater extension of service or heavier service

NUMBER OF BULLS The number of inseminating units and the number of cows enrolled are the determining factors in the number of bulls needed A stud will usually maintain from 4 to 10 or more bulls of each breed The number varies for many reasons Most studs ship semen 6 or 7 days per week others ship 3 or 4 days per week Some keep a full complement of proved bulls and ship additional semen from young bulls Some bulls can be collected from more often than others Most bull studs do not use a bull oftener than once a week

Inseminating Associations or Units

An inseminating association or unit is composed of a number of dairymen located within a limited area The purpose of the group is to have their cows bred artificially In practically all cases it is organized as a cooperative A few operate privately The organization receives semen from a bull stud A technician (inseminator) is employed to do the breeding

The extent of the area included should not be greater than a 20 mile radius from the central location It is preferable to include only one county unless they are small or where one natural trading center serves more than one county An area greater than this will involve too much travel from the standpoint of time and economy

Number of Cows A minimum of 1200 to 1500 cows within this area is essential usually for economical operation Organizations that begin operation with less than this number may find difficulty in their finances or will have to charge a higher insemi

nating fee. Few associations with part-time inseminators have proved successful.

In the United States, there were 1653 inseminating units in 1951.* On the average, each bull stud serviced 17.5 units. Each inseminating unit contained an average of about 2100 cows.

The Artificial Breeding Organizational Setup

The organizational setup varies greatly from one state or area to another. A plan that is working successfully in several states will be discussed. The over-all organization is the Artificial Breeding Association, which should be located where there is easy transportation to every part of the area covered. This association is often statewide and is responsible for the complete operation of the bull stud. Each inseminating unit is an affiliated member and furnishes a director to the governing board of the parent organization.

Each member of the local unit pays a membership fee. This may be 5 or 10 dollars or some other amount that is agreed upon. A portion of this fee remains with the local unit to provide the necessary equipment and the other portion is paid to the parent association. This fee is paid only at the time of becoming a member. A breeding fee is charged at the time of service. This fee is usually from 5 to 7 dollars. On the average, about 40 per cent of this is paid to the parent association and 60 per cent is retained by the local unit to pay the inseminator and to take care of equipment and other costs.

The main organization operates the bull stud on the money received from membership fees and its part of the inseminating fees. The inseminating fee is charged at first service. Two more services to the same cow are furnished without additional cost, if required to get the cow in calf, after which there is an additional fee.

Collecting the Semen

Three methods are used to collect semen. The use of the artificial vagina is the accepted method of collection under most

* *U.S.D.A., D.H.I.A. Letter*, 28.3 (1952).

conditions The massage method and recovering semen from the vagina of a cow recently bred are occasionally used

Dairymen occasionally wish to check the quality of the semen of a bull that is used in natural service Any of the above methods may be used to secure the sample of semen for examination The normal ejaculate provides from 3 to 6 milliliters in volume

The Artificial Vagina. The artificial vagina is composed of a hard rubber cylinder 12 to 16 inches long and 2 to 2¾ inches in diameter (a truck radiator hose is satisfactory) with a soft rubber liner placed inside and turned back over the ends to form a water jacket A rubber cone with a glass tube on the small end is placed on one end of the cylinder Hot water is put into the jacket to bring the temperature of the inside of the vagina to about 110°F A sterile lubricating jelly or white Vaseline is applied to the inside of the vagina for lubrication

The bull is then allowed to mount a cow, another bull, or a dummy cow As he mounts, the semen is collected in the artificial vagina Collections can be made from most bulls by this method a few, however, refuse to serve This method gives the best quality semen available It is clean and usually has a high concentration of sperm

Massage Semen can be collected by massaging the accessory genital organs of the bull with the hand, by way of the rectum The semen is collected into a funnel and test tube from the sheath This method does not give a very good quality of semen and it usually is contaminated This was one of the early means of securing semen It is occasionally used on crippled bulls or others that cannot or will not mount a cow for some reason

Recovering Semen from the Vagina The oldest and simplest method is to obtain the semen from the vagina of a cow after a natural service A long tube attached to a syringe can be used to withdraw some of the semen Semen secured in this way is diluted and mixed with the secretions of the vagina which lowers its quality With this method there is a danger of transmitting disease from the cow to another cow bred with the semen

Examining, Processing, and Storing

The first step after collection is to examine the semen under a microscope The examination shows the motility and the number of dead or abnormal sperm, which give an indication of the quality of the semen It is not always possible, however, to determine the quality of the sperm by such examinations

Processing. If the semen is to be used within 30 minutes it is not necessary to cool or to add diluters to it When several cows are to be bred or if it is held longer than 30 minutes before using, a diluter should be added to the semen as soon as the examination with the microscope has been made It should then be placed in a refrigerator to cool to 35 to 40°F

Diluters or Extenders. The purpose of using a diluter is to prolong the life of the sperm and to extend the volume of semen The materials in the diluter control the *p*H of the mixture, provide energy, and protect the sperm from shock under conditions of storage and use

The diluter and semen should be about the same temperature, preferably about 80°F when mixed The amount of dilution to use depends upon the quality of the semen and the number of cows to be bred A dilution rate of 1 part of semen added to 40 or 50 or even 100 parts of diluter is often used

There are many kinds of diluters Commercial diluters are recommended where only a small quantity is occasionally needed The ingredients may be secured and the diluters prepared in the laboratory Changes are being made in the formulas for diluters as improvements are discovered

The two diluters that are most widely used are the phosphate-egg yolk diluter and the citrate egg yolk diluter Each of these has good preservative properties The citrate disperses the fat globules of the egg yolk so that the sperm can be seen more clearly upon microscopic examination

The phosphate diluter is made by adding 2 grams of sodium phosphate ($Na_2HPO_4\ 12H_2O$) and 0 2 gram of monopotassium phosphate (KH_2PO_4) to 100 milliliters of boiling distilled water All reagents must be chemically pure

The citrate diluter is made by dissolving 3 grams of sodium citrate ($Na_2C_6H_5O\ 2H_2O$) in 100 milliliters of boiling distilled

water (the water should be distilled in glass) The buffer, either phosphate or citrate, is used with fresh egg yolk in the proportion of 70 per cent buffer and 30 per cent egg yolk Boiled skim milk has been found to be a suitable diluter and is being used by some breeding centers It is heated to 203°F in glass for 10 minutes

Antibacterial Agents The addition * of 1000 units of penicillin or 1000 units of streptomycin per milliliter of the diluter, or a combination of the two, may improve the fertility of semen Based on 6 months nonreturns these antibiotics gave an increase of from 19 to 26 per cent over the same semen and diluter without the antibiotic The increase in fertility is greater with semen from bulls of low fertility than with more highly fertile bulls

Cooling The diluted semen, at room temperature or above should be placed in a refrigerator at once Slow cooling is necessary to protect the sperm from cold shock Tubes of diluted semen may be set in a small beaker of water of similar temperature and the beaker placed in a refrigerator at 34 to 40°F This method will cool the entire mass at the rate of about 1°F per minute if small beakers are used

Shipping The semen is usually shipped in test tubes varying in volume from 2 to 20 milliliters depending upon the number of cows to be bred The tubes should be filled to exclude air so that there will be less deterioration of the semen The tubes are wrapped in heavy paper and packed with a can of ice in an insulated shipping case The temperature should be kept below 40°F during transit. The size of the can of ice may vary depending on the outside temperature and the length of time that it will be in transit This method of packaging will keep the semen in good shape for a 24 hour shipment For longer shipments a greater amount of insulation must be used and more precautions taken in the packaging of the semen

Inseminating the Cow

The technique of inseminating the cow is the placing of a small volume of semen usually about 1 milliliter, in the uterus

* *J Dairy Sci* 33 393 (1950) and 34 819 (1951)

or in the folds of the cervix of the cow. Two methods are in general use.

1. Speculum Method. In this method a speculum is inserted into the vagina of the cow. A flashlight is used to throw light on the cervix. The semen is drawn into a long, thick-walled inseminating tube by the use of a small syringe. The inseminating tube is inserted through the speculum and into the mouth of the cervix. By use of the syringe the semen is forced from the inseminating tube into the cervix. This method is used largely where the breeding is being done within the herd, but is not usually used in large-scale operation. The technique is simpler than the uterine method.

2. Uterine Method. The uterine method is used most extensively by trained technicians. A rubber glove is used on one hand, which is inserted into the rectum. The cervix is grasped with the hand through the rectal wall. The inseminating tube is inserted into the vagina and guided into the cervix. It can be placed entirely through the cervix and into the body of the uterus. Usually, the technician deposits a portion of the semen in the folds of the cervix and the remainder into the body of the uterus.

Workers at Illinois and New York Experiment Stations * found no difference in the breeding efficiency when the semen was placed in the folds of the cervix or in the body of the uterus. The speculum method (depositing the semen in the mouth of the cervix) was compared with the uterine method (placing the semen in the uterus), by workers at the Missouri Station.† The uterine method was 10 to 12 per cent more efficient when semen more than 12 hours old was used.

Efficiency of Artificial Insemination

The rate of conception with artificial insemination can be expected to be about the same as with natural breeding. There is nothing magic about it that will cure the ills of sterility or low fertility. A few bulls produce semen that will not stand up under storage and shipment, yet give good results with natural

* *J. Dairy Sci.*, 34:1, p. 68 (1951).
† *Mo. Exp. Sta. Bul.* 540 (1950).

service. In artificial breeding a sterile bull or one with a very low grade semen may be found by examining the semen under the microscope; however, a dairyman would most likely use this same bull at least 3 or 4 weeks before discovering that he was sterile.

The efficiency of natural and artificial services was compared at Nebraska.* The results are given in Table LXV.

TABLE LXV

NATURAL AND ARTIFICIAL SERVICES COMPARED

Kind of Service	Actual Conceptions, number	Cows Conceiving at Service Indicated: First, per cent	Second, per cent	Third, per cent	Fourth, per cent	Fifth or More, per cent	Sterile Cows, per cent	Services per Conception (Fertile Cows), number
Natural	[illegible] 681	60.1	18.6	[illegible] 9	3.[illegible]	3.7	6.[illegible]	1.80
Artificial	5,[illegible]39	61.4	17.7	7.8	3.9	1.7	6.5	1.63
All artificial service in one herd (8 years)	639	60.3	18.3	7.8	4.2	3.9	5.5	1.[illegible]0

Measuring Breeding Efficiency

Artificial breeding associations measure the breeding efficiency of a bull on the basis of nonreturns. If a cow is bred and the owner does not call the inseminator back to rebreed her, she is considered a nonreturn. All nonreturns are not actually with calf. The cow might have later been bred naturally, she might have been sold, or there might have been other reasons for not rebreeding her. A satisfactory record is 70 per cent nonreturns up to 60 days or a 60 per cent nonreturn up to 90 days after breeding. This, of course, is higher than the actual pregnancies. When an average of less than two services are required per actual conception, the breeding record is satisfactory.

Relations with the Breed Registry Associations

The main purposes of the purebred registry associations when they were first organized were to record the pedigrees of the

* *Nebr. Res. Bul.* 129 (1943).

animals registered in order to maintain the purity of the breed With the breeding of purebred cattle artificially, the Purebred Dairy Cattle Association set up certain requirements for the registration of calves dropped as a result of artificial breeding This action was taken since there was more opportunity for error in preparing the application for registry, especially in regard to the sire Also, there was more chance of falsifying the records The additional requirements are the same for all five breed-registry associations

Within the Herd. When a breeder or his agent collects semen from his own bull and inseminates his own cows, no special forms are required

Between Herds. When semen is taken from a bull in one herd and used to inseminate a cow in another herd, a special form is required The owner of the bull certifies to the collecting of the semen and the owner of the cow certifies (on the same certificate) to the inseminating of the cow This certificate is attached to the application for registry of the calf produced by the service

From Association When the technician for an association breeds a cow he prepares a breeding receipt in triplicate and gives the owner of the cow the original This certifies to the semen used, gives the date, and states that the cow was identified by the use of her registration papers This breeding receipt is attached to the application for registry of the calf

Blood Type of Bulls The breed associations require that all bulls used in artificial breeding organizations or between herds must be blood typed and the record filed with the breed association concerned Should a cow be bred more than once and semen from different bulls used, and the date of calving is midway between the dates due from two services, the blood type will be used to determine the sire The blood type of the calf and its dam will also be needed The blood type record may be used for other cases of questionable parentages

Records The bull stud must keep a record of all semen collections and shipments Reports are sent to the breed association office

Inspection A representative of one of the breed associations inspects the bull stud each year He checks the records and the general accuracy and carefulness of the work

Certification A representative of the agricultural college in the state concerned must approve the bull stud The manager of the breeding association must approve the inseminator

Other Records

A breeding association needs to maintain a complete set of records that will show the rate of nonreturns for each bull and for each inseminator A copy of the inseminator s receipt gives the basic data for much research work

REFERENCES FOR FURTHER STUDY

1 Perry, *The Artificial Breeding of Farm Animals* Rutgers University Press, 1952
2 Lambert and McKenzie Artificial Insemination in Livestock Breeding *U S D A Circ* 567 (1940)
3 Winters and Associates Artificial Insemination of Farm Animals *Minn Exp Sta Bul* 336 (1938)
4 Miller and Evans Technique for Obtaining Spermatozoa *J Agr Research* 48 10 (1934)
5 Herman and Ragsdale Artificial Insemination of Dairy Cows *Mo Exp Sta Bul* 540 (1950)
6 Herman and Madden, *The Artificial Insemination of Dairy Cattle* Lucas Bros Columbia Mo 1947
7 Erb and Morrison Artificial Breeding of Dairy Cattle *Wash Ext Bul* 331 (1951)
8 Gilmore *Dairy Cattle Breeding* Lippincott, 1952
9 Almquist A Comparison of Penicillin Streptomycin and Sulfanilamide for Improving Semen *J Dairy Sci* 34 8 (1951)
10 Olds and Seath, Predictability of Breeding Efficiency in Dairy Cattle *J Dairy Sci* 33 12 (1950)
11 Salisbury and VanDemark, The Effect of Cervical, Uterine and Cornual Insemination on Fertility of the Dairy Cow *J Dairy Sci* 34 1 (1950)

25

Maintaining Breeding Efficiency

Profitable milk production and the improvement of dairy cattle is dependent upon normal reproduction Cows will produce more milk and will produce it when it is most needed when they freshen at about a 12 month interval When cows fail to conceive at the first or second service, usually a loss in production results that may disrupt the plans for milk production, causing a lowering of the base and other inconveniences Any factor that lowers breeding efficiency will lessen the rate at which herd improvement can take place Many outstanding family lines of livestock have become extinct because of impaired reproductive ability Thousands of animals are lost from the herd, and many dollars worth of feedstuffs are wasted each year by animals whose value has been reduced due to reproductive failure The loss then is not only due to decreased milk production but also to the waste of much feed and the decrease in the value of valuable animals

Sterility, which is the complete absence of reproductive ability, usually is easy to recognize, but lowered fertility, which is subnormal breeding efficiency, is not so easily detected, and such animals sometimes cost the breeder more than do those that are completely sterile because they are often kept in the herd in the hope that fertility will be restored Dairy cattle that are barren and dry for months are costly, in terms of space in the barn, feed, and labor

Sterility and lowered fertility are not a single problem They have many different causes, among which are specific infectious diseases, infections of the uterus, or structural abnormalities Low fertility may result from heredity, poor nutrition, poor management methods, reduced viability of the male sperm cells, or failure to breed the cow at the most favorable time

Certification A representative of the agricultural college in the state concerned must approve the bull stud The manager of the breeding association must approve the inseminator

Other Records

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MEASURING BREEDING EFFICIENCY

Several methods are used to measure breeding efficiency, any one of which may be used, depending somewhat upon the conditions and especially upon the information available

(*a*) The number of services per conception is used as a measure of breeding efficiency Workers at Nebraska Station * found that under their conditions the number of services required for conceptions for fertile cows ranged from an average of 1 63 to 1 80 services per cow for various groups, but when total services to all cows were included, an average of 2 services per cow were required A study at Minnesota † found the following percentages of conception for the first and successive services first, 42 7, second, 35 3 third, 31 3 fourth, 25 8 fifth, 26 1, and sixth, 20 4 Later services gave an even lower rate of conception As a general rule, if less than 2 services per conception are required, the breeding record is satisfactory If more than 2 services are required, there is probably some trouble with the herd which should call for the services of a veterinarian Cows requiring more than three services are problem cows

(*b*) The percentage of nonreturns is the measure used in most artificial breeding associations to measure the breeding efficiency of bulls A nonreturn is an animal that has been bred and for which there is no request for another breeding This, of course, is not an exact measure as the actual conceptions will be less than the nonreturns would indicate Some cows may die, others may be sold, still others may be bred naturally, so that the nonreturns are not an exact measure of breeding efficiency The length of time after breeding that the nonreturns are counted will also affect the percentage An acceptable record is 70 per cent nonreturns up to 60 days after breeding or 60 per cent nonreturns up to 90 days after breeding

(*c*) The length of the calving interval would be ideal if a cow calved every 12 months This is seldom achieved in practice as usually some of the animals will fail to conceive at first service When a dairy herd averages less than 13 months between calving

* *Nebr Res Bul* 129

† *Minn Exp Sta Bul* 258

TABLE LXVI

LENGTH OF CALVING INTERVAL IN THREE HERDS

Herd	No of Cows	Length of Calving Interval: Months	Days
A	29	12	27
B	24	12	10
C	45	13	0

it is considered a highly fertile herd Table LXVI gives the length of calving intervals in three herds that were attempting to have their cows freshen at 12-month intervals

Some herds average as long as 14 to 15 months between calving Long calving intervals are conducive to high lactation records, but lower average milk production per year In making advanced registry records, cows are often held open in order to get the higher lactation records This causes a long calving interval, which usually results in a longer dry period Thus, the dairyman who wants high milk production for his herd each year with a higher lifetime production will attempt to have his cows freshen as nearly as possible each 12 months It is not wise to shorten the period much below 12 months A cow requires at least 2 months to come back to normal after freshening, so that she should not be bred until she has had a chance to return to normal condition

(*d*) The percentage of cows that calve within a year has been used to estimate the breeding efficiency of a herd A fertile herd should produce a 90 per cent calf crop each year This will vary greatly

(*e*) The number of days per year that a cow carries a calf has been used as a measure of reproductive efficiency If a cow carries a calf 9 months of a year she is rated as having a reproductive efficiency of 100 per cent

Gilmore [*] and others have developed the following formula for estimating the reproductive efficiency of dairy animals

[*] L O Gilmore, *Dairy Cattle Breeding*, J B Lippincott Co, Chicago, 1952

$$\text{R E} = 12 \times \frac{\text{No of calves born}}{\text{Age of cow (mo)} - \text{age at first breeding (mo)} + 3} \times 100$$

For example, a 5 year old cow (60 months) which was success fully bred at 15 months of age and had dropped 4 calves would have a 100 per cent reproductive efficiency as shown in the fol lowing formula

$$\text{R E} = 12 \times \frac{4}{60 - 15 + 3} \times 100 = 100 \text{ per cent}$$

If, however, she was 6 years old (72 months) the results would be as follows

$$\text{R.E} = 12 \times \frac{4}{72 - 15 + 3} \times 100 = 80 \text{ per cent}$$

With such a system, the reproductive efficiency of each animal in the herd can be determined It is practically impossible to get a herd with a reproduction efficiency of 100 per cent, and so it should be used only as a goal

CAUSES OF LOW BREEDING EFFICIENCY AND FERTILITY

The causes of low fertility are many and varied A few of these will be discussed

1 Inheritance That certain cow families inherit low fertility and breeding efficiency has been shown by several workers The Louisiana Station * reported on some cow families that varied from 40 6 to 92 3 per cent in breeding efficiency with an average of 63 3 per cent, basing their percentage on 1 service per con ception as 100 per cent The Nebraska Station † found great variations between families The families studied ranged from 54 to 87 per cent using the formula for measuring reproductive efficiency The West Virginia Station ‡ in studying nineteen

* *La Exp Sta Bul* 370 (1943)
† *J Dairy Sci* 28 659–669 (1945)
‡ *J Dairy Sci* 34 95–105 (1951)

families of Ayrshire cows, found that these families varied from 77 to 89 per cent in reproductive efficiency These nineteen families varied also in the number of services per conception from 1 6 to 3 1 There seems little doubt that reproduction efficiency is an inherited character

Certain families do not even reproduce sufficiently to maintain themselves For example, in 1917, a herd of 121 females was given to an experiment station * At the end of 10 years, 62 8 per cent of the original 121 families had become extinct, most of them producing no female progeny, but several lasted until the fourth generation before finally disappearing Other families are extremely fertile and in a short time an entire herd may be descended from only one or two foundation animals Longevity has a marked effect on the number of descendants Longevity is, however, influenced by regular breeding, since nonbreeders and slow breeders are usually sold for slaughter at an early age and their ability to live to an old age is not ascertained

Inbreeding of dairy animals may also cause a lowering of the reproduction efficiency Inbreeding itself does not cause lower reproductive efficiency, but it may be responsible for bringing together in a homozygous condition the genes which bring about lower reproductive efficiency This concentration of genes may not in itself affect breeding efficiency, but may bring out some character, such as lack of thrift, which may have the same results as if it affected fertility directly Certain inherited characteristics also affect the reproduction of animals Among these are the following

(a) FREEMARTINS A heifer born co twin with a bull is sterile in more than 90 per cent of the cases, the heifer of such a birth is called a freemartin It is important that the breeder know as early as possible whether or not the heifer will breed, otherwise he may have the expense of raising an infertile animal A study of freemartins shows that this condition occurs only in females whose blood stream is joined to that of a male (or males) and that the primary abnormality is found in these females in the repro ductive tract and secondarily in the mammary gland These changes result in a more or less developed male reproductive

* Thesis for Master s Degree, W Va University 1928

tract in an animal that started out genetically to be a female Some of these freemartins take on definite masculine characteristics, such as coarseness of the neck, a deep masculine voice, palpable testes, and even a rather well developed penis, whereas others retain their feminine appearance and even sometimes exhibit heat

In order to tell whether it is a true freemartin at an early age, the herdsman should determine at the time of birth, whether the calves were born in the same placenta If this is impossible to determine, the calf can be watched to see if it makes normal udder development during the first 3 or 4 months The size of the vagina may also be a fairly definite indication of a freemartin If a test tube can be inserted into the vagina only 3 to 3.5 inches, the animal is probably a freemartin, in a normal heifer the test tube can be inserted the full length The blood antigen type can also be used When the male and female have identical blood types,* the indication would be that the embryonic circulation had been the same and that the heifer would not breed If the blood types are dissimilar, the heifer should be a normal breeder

Twinning and multiple births in dairy cattle is an inherited character They occur in less than 2 per cent of calvings in dairy breeds and in only about 0 4 per cent in beef breeds

(b) White Heifer Disease. This is a form of sterility first observed in white Shorthorn heifers It is caused by the development of a membrane separating the vagina from the uterus, thus preventing the sperm from entering the uterus Sometimes another structural abnormality may exist This is not a disease and sometimes can be corrected by surgery Apparently it is inherited

(c) Cryptorchidism Occasionally, a bull calf in born with one or both of the testes retained in the abdominal cavity If both of the testes are retained the bull probably will be completely sterile If one testis descends into the scrotum it will produce normal sperm but the one held within the body cavity will not produce normal sperm because of the higher temperature within the body This defect is called cryptorchidism and is inherited Such bulls, even though they are fertile, should not be used because of the inherited character

* *Science*, 102 400

(d) MISCELLANEOUS INHERITED DEFECTS There are many defects that occur with more or less frequent intervals that interfere with the breeding efficiency Such things as lethal or sublethal factors may occur, but of course must come from both parents When they do occur they may cause death or arrested development in the developing embryo, the fetus, or the young animal Twenty-eight different lethal factors have been reported

2. Infectious Diseases. Several infectious diseases cause breeding trouble These are brought about by microorganisms and are infectious. Most of these will be discussed in the lecture on diseases of dairy animals and will only be mentioned here

(a) BRUCELLOSIS OR BANG'S DISEASE This is an infectious disease that affects breeding animals and often causes premature birth or expulsion of a dead calf It is caused by the organism *Brucella abortus* An estimated 25 to 30 per cent of the animals that contract this disease become either temporarily or permanently sterile Effective means are available for combating it

(b) TRICHOMONIASIS This disease is caused by a single-celled protozoan known as *Trichomonas fetus* This organism lives in the sheath of the bull and the uterus of the cow It causes early abortions and is an important factor in the lowering of breeding efficiency of infected animals

(c) VIBRIO FETUS This organism, *Vibrio fetus,* is a comma-shaped bacterium which apparently interferes with the circulation of blood in the placenta, often causing abortions, usually in the middle third of pregnancy

(d) OTHER INFECTIOUS DISEASES Vaginitis, cervicitis, and metritis may affect breeding efficiency Metritis, which is an infection of the uterus itself, will keep the cow from becoming pregnant until the infection is cleared These diseases require specialized treatment under the direction of a veterinarian

3. Functional Disturbances. When reproduction is not normal and the animal is not infected with a recognized infectious disease or does not have a definite structural defect, the trouble is classified as a functional disturbance Some of these conditions are as follows

(a) RETAINED CORPUS LUTEUM A persistent yellow body, often referred to as a retained corpus luteum, will prevent a cow

from coming into heat. When a cow ovulates, a corpus luteum or yellow body is formed where the egg was discharged If the cow is bred and conceives, the corpus luteum remains in the ovary during pregnancy If the cow is not bred or is bred and does not conceive, the corpus luteum usually disappears within 21 days and the cow will come into heat Sometimes, for unknown reasons, the corpus luteum does not disappear and so prevents the cow from coming into heat It must be removed manually or with the use of hormones before the animal will again have a normal estrus cycle

(b) Cystic Ovaries or Nymphomania In some cases a cyst may develop on the ovary and cause short estrus cycles or prolonged estrum The animal usually will not conceive if bred at these abnormal heat periods These animals are often referred to as chronic bullers and the condition is called nymphomania. Some cows may develop a high tail head and the animal may bellow and exhibit other masculine characteristics The cyst may be removed manually or treated with certain hormones by a veterinarian but the cow usually will not breed until she has passed one or two normal heat periods

(c) Other Troubles. The entire reproductive process is dependent upon hormone secretions Should there be a deficiency or an overabundance of one of these, a hormonal imbalance occurs that may interfere with breeding efficiency Hormone therapy should be used only after a specialized examination indicates that its use would be of benefit

The diagnosis and treatment of any abnormal conditions as described, should be made and carried out under the direction of a veterinarian

4 Nutritional Causes of Lowered Fertility Under normal conditions, animals that are well fed and thrifty and receive much of their nutrients from good pasture and roughage should have few breeding troubles caused by faulty nutrition However, there are some conditions that should be avoided, such as the following.

(a) Poor Nutrition Poor nutrition may account for a lowering in the breeding efficiency It has been noted that sometimes animals that fail to breed during the winter months give no difficulty after they go on pasture in the spring. Nutritional de-

ficiency should be suspected when the ration is obviously poor or unbalanced, when the animals are dull and listless, when the skin is dry and scaly and the hair rough, and when digestive disturbances are common This condition may be due to a lack of carotene, the provitamin A, or perhaps to vitamin D, although this is not probable if the animals are exposed to the sunlight There is still some question whether the minerals play a large part in breeding efficiency The lack of three minerals, namely phosphorus, calcium, and manganese, are more frequently blamed for reproductive disorders than any others They are essential for growth and therefore should be added to the ration in adequate amounts

The level of feeding affects the age of sexual maturity Studies at the New York Station * showed that Holstein heifers fed normal rations came in heat for the first time at an average age of 11 3 months, heifers on a subnormal ration (65 per cent of Morrison's Standard) averaged 17 3 months of age, and those on a supernormal (140 per cent of Morrison's Standard) averaged 9 4 months The heifers fed the normal ration required 1 22 services per conception, those on subnormal, 1 56 services, and those on the high level, 1 33 services per conception

(b) EXCESSIVE CONDITION Animals carrying excessive conditioning usually are slow breeders Heavy fat deposited around the ovaries is thought to interfere with normal functioning of the ovary Animals that are fitted and kept in high condition for long periods of time for show or sales purposes are apt to have breeding trouble Judges now discriminate against overconditioned dairy animals It is never wise to keep breeding bulls too fat

5 **Management Factors in Breeding Efficiency.** Some factors affecting breeding efficiency are entirely the responsibility of the herdsman and are not connected with any of the troubles already described Some of them cannot always be helped but it is well to know about them and be prepared for the results

(*a*) Holding cows open too long may sometimes be a factor which causes low conception rates This may be thought necessary in order to make a large 365 day record, or, more especially,

* *J Dairy Sci*, 34 510 (1951)

to have the cows and heifers freshen at the time of year when milk is in greatest demand, usually in the fall of the year Heifers that are kept to an older age before breeding should not be fed heavily on grain

It should be understood that each time a cow or a heifer goes through the estrus cycle an additional chance is given for some abnormal condition to develop that may cause a lowered breeding efficiency Such things as retention of the yellow body, the

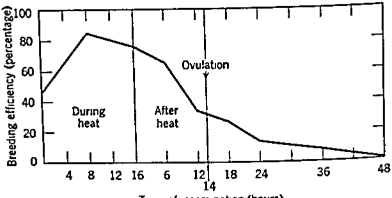

FIG 40 Relation of time of insemination to breeding efficiency (*based on data from Nebr Res Bul 129*)

development of a cyst, or other abnormalities may occur The sooner a cow is rebred after she becomes normal after freshening, the better is the chance for conception

(*b*) Breeding too soon after freshening will decrease the conception rate It is best for a cow to pass through two estrus cycles after calving before breeding her again If she is normal she may safely be bred on the third heat period, but if she has had a retained placenta, or shows any discharge of any kind, she should be held until she has completely recovered

(*c*) The period in the estrus cycle during which the cow will mate is called the estrum or heat period Most dairy animals show definite signs of heat, such as mounting other cattle, standing for others to mount them, and general nervousness The estrus cycle averages about 21 days in length, but varies from 16 to 28 days The heat period will usually last for from 14 to 18 hours, but may vary, and it ranges from 12 to 24 hours in

length The time of service during this heat period may be of great importance. Ovulation does not take place until about 14 hours after the end of heat For this reason, cows bred after going out of heat may conceive, provided that it is not too long after the heat period The sperm must meet and fertilize the egg while they both are alive and active

The Nebraska Station * found that breeding during the last half of the heat period gave the highest conception rates Difficult breeders are sometimes bred twice during the heat period, from 6 to 8 hours apart Figure 40, based on data from the Nebraska Experiment Station, shows the best time to breed to get the best breeding efficiency

(*d*) Probably one of the greatest causes of delayed breeding, and, hence, of low breeding efficiency is failure to recognize when a cow is in heat Some cows do not show when they are in heat and require careful observation by the herdsman This is especially true when the cows are not turned out together during the winter months A good herdsman will be careful to observe every cow every day A careful record of breeding dates would give him indications of the time to watch the cow

The following system, Table LXVII, is used in New York to determine when a cow should be bred artificially

TABLE LXVII

TIME TO BREED CATTLE ARTIFICIALLY FOR BEST RESULTS

Heat First Observed	When to Breed	Too Late
In the morning	The same day	The next day
Afternoon or evening	Forenoon next day	After middle of afternoon next day

The duration of estrus was observed at the Nebraska Experiment Station, cows remained in heat longer than heifers Those first observed in heat in the afternoon remained in heat longer than those first observed in heat earlier in the day, as shown in Table LXVIII

Breeding Records Breeding records are essential in achieving and maintaining a high breeding efficiency in a dairy herd The

* *Nebr Res Buls* 129 and 153

TABLE LXVIII

AVERAGE DURATION OF ESTRUS ACCORDING TO TIME OF DAY

	Heifers		Cows	
Estrus First Observed	Number	Hours	Number	Hours
Before 9:00 A.M	23	14 3	43	16
9:00 A M to 12:00 noon	7	14 6	16	18 1
After 12:00 noon	16	17 1	27	20 4
Average		15 3		17 8

records needed are (*a*) dates animals come into heat, (*b*) service dates, (*c*) sire used, (*d*) date cow is due to calve, (*e*) date the cow calves, (*f*) health history of cow following parturition, such as difficult calving, retained placenta, metritis, etc.

A complete record of the breeding and reproductive history of every animal in the herd will aid in the following ways

(*a*) Locate cows with previous difficult breeding trouble

(*b*) Indicate cows that may need to be treated before breeding because of retained placenta, metritis, or other troubles

(*c*) Show the approximate date that the animal should come in heat.

(*d*) Show whether or not the heat period is regular

(*e*) Aid the veterinarian in making a proper diagnosis of breeding trouble

Carrying Out the Program. Much of the breeding efficiency of a dairy herd depends upon the health of the herd, and the efficiency of the herdsman No program is any better than the manner in which it is carried out. The herdsman should first of all free the herd as far as possible of all infectious diseases and then take every precaution to see that the details are carried out. Nothing will so interfere with the profit from a herd as a low breeding efficiency

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Dairy Cattle Health

One of the greatest ravages of the profits of dairy farms is disease. Each cow sold for slaughter represents a loss to the extent of the difference between the beef value and the value of a similar cow for dairy purposes. Asdell * made a survey of cows removed from dairy herds, the summary of which is given in Table LXIX. This study covered seventeen states and included

TABLE LXIX

REASONS FOR COW REMOVALS FROM D H I A HERDS

Reason for Removal	Per Cent
Dairy purposes	23.4
Low production	33.5
Udder trouble	11.5
Abortions	7.4
Sterility	8.2
Died	5.0
Old age	2.8
Other reasons	8.2

nearly 600,000 cows that were removed from Dairy Herd Improvement Association herds. An average of 21.9 per cent of all cows in these herds were removed yearly. This varied considerably from one state to another.

Seventy-six per cent of those leaving the herd were removed for reasons other than for dairy purposes. More than one half of this group were lost through injury, disease, or death.

Herd health depends on careful management as well as on freedom of disease. A good herdsman will maintain conditions that are not conducive to injury of the animals or the spread of

* J. Dairy Sci. 34:529 (1951).

diseases He may observe conditions in animals that are not entirely normal before the difficulty has caused much damage An animal may not eat her feed as eagerly as usual or not clean it up, she may stand uneasily in her stall, her hair may stand up on her abnormally, the dung may be too soft or too hard in consistency and its amount may not be normal, her milk flow may be low, she may stay away from other animals in the barn or pasture, or she may show other abnormal behavior An alert herdsman will attempt to locate the trouble and correct it before it becomes critical, or, if it is an infectious disease, prevent further spread of it as far as possible

The herdsman should know the symptoms of some of the more common dairy cattle diseases so that he may employ necessary preventive measures First aid and minor treatments should be administered by the herdsman, but the more serious cases should be treated by a veterinarian The training and the experience of the herdsman and the availability of a veterinarian may determine to some extent the amount and kind of treatments that the herdsman will attempt to give He should in a general way decide the type of herd health problems that he will attempt to care for and then equip himself to handle them to the best advantage When animals require the services of a veterinarian, he should be called without delay so that the most efficient treatment and effective results can be had

Good herd health management includes cleanliness, isolation of sick or injured animals, protection from poisonous plants and materials, and having premises free of equipment and other objects that may cause injury to the animals

Cleaning and Disinfecting Barns and stalls that are constructed of concrete and metal stanchions and partitions are much easier to clean than buildings of wood construction A thorough cleaning should be made with a brush and a hot lye solution or a hot solution of an alkali washing powder and a wetting agent

The cleaning should be followed by the use of a disinfectant over all surfaces This can be applied with a sprayer or a sprinkler Coal tar or creosote disinfectants are recommended, except in the milking barn or the milk house, where milk would absorb the odor Chlorine can be used in these places When

there is considerable cleaning to be done, the use of a high-pressure steam jenny will help to make the job much easier.

Isolation. A well managed herd will have complete isolation facilities that will be available for animals with any disease that might be contagious or infectious Sick and injured animals should be isolated from the rest of the herd Isolation will help protect the rest of the herd from disease Animals that are to be brought into the herd should be isolated for a period of 3 or 4 weeks or longer, until they can be retested or until they have had sufficient time for any disease to develop that might be dangerous to the health of the herd

The attendant caring for animals in isolation because of contagious diseases, should not go directly from the isolation stable to the other cattle He should wear different clothes, and should thoroughly wash and disinfect his shoes and his hands

Poisons There are many poisonous chemicals and plants that may kill animals Probably the worst offender is lead paint, on fences or buildings to which animals have access, and discarded paint buckets and brushes Fertilizers, especially nitrates, will kill cattle if they are where the animals can lick them from the bag or when spilled in a pile in the pasture Sprays, rat poisons, and other poisonous materials should be stored so that animals cannot get to them

A large number of plants are poisonous to animals They are more dangerous when pastures are short and animals are not as selective in their grazing. Some of the common poisonous plants are larkspur, corn cockle, rubberweed, water hemlock, the poisonous milkweeds, jimson weed, rayless goldenrod, and locoweed Also, immature sorghum and Sudan grass, and wilted wild cherry leaves contain hydrocyanic or prussic acid If very much is consumed, it is fatal Acorns will cause milking cows to dry up Cattle of any age are affected by severe digestive disturbances from eating acorns

Foreign Bodies or Hardware Disease A large number of dairy cattle are lost every year from foreign bodies Metal objects, especially those with a sharp point, such as nails, pieces of wire, and staples are dangerous when swallowed by a cow Since the cow does not thoroughly masticate her feed before swallowing, these materials are sometimes taken in with the feed.

When swallowed they tend to move forward into the reticulum, which may be only an inch or less from the heart. If the object passes through the wall of the reticulum it may result in peritonitis, which causes the cow to drop suddenly in milk and to go off feed. Unless the foreign body is removed by surgery, the peritonitis may become more severe and be followed by abscessation in various parts of the body and eventually death. The metal may penetrate the pericardium, or heart sac, a condition for which there is no treatment.

Prevention consists of eternal vigilance in picking up all pieces of wire, nails, or other metal that might get into the feed. Most feed companies pass feed over a magnet in order to remove any pieces of metal. Some farm mills have a magnet built into the feed chute.

DISEASES

Tuberculosis. At one time, tuberculosis was the most important disease of dairy cattle. An effective control program, carried on by the federal government in cooperation with the various states, has reduced infection in dairy cattle to less than 0.5 per cent. The control program consists of testing the animals with tuberculin, and any reactors are slaughtered.

An accredited tuberculosis-free herd is one which has had 2 clean annual tests. To retain this status, the herd must continue to be tested yearly, with all animals passing the test. A modified accredited area may be a county or a state in which all cattle are tested and where not over 0.5 per cent reactors are found. Also, the herds where reactors were found must be retested at intervals until all animals in it are found to be negative. All health ordinances dealing with the sanitary production of milk require that the herd be tested annually.

Brucellosis (Bang's Disease). Brucellosis, sometimes referred to as Bang's disease or infectious abortion, causes heavy losses to the dairy-cattle industry. It is caused by an organism known as *Brucella abortus.* About 90 per cent of abortions in cattle are caused by this organism, although abortions may have other causes, such as injury, strong medicine, and improper feeding. This organism may also cause Brucellosis, or undulant fever, in man. A number of cases of this disease contracted from raw

milk, from meat products, or from contact with infected animals have been reported

In the dairy herds, the loss due to Brucellosis is not due alone to the loss of the calf, but also to such factors as the loss of many cows on account of their weakened condition retained afterbirths and metritis, which often lead to sterility, shy breeding, loss of flesh, loss in milk flow, lowering the sales value of the animal, and extra labor required for handling an infected herd It is particularly costly to purebred breeders since they lose not only from the interference with their milking and breeding program but also from the sale of breeding stock The Livestock Sanitary Association * reported that in 1949 the loss from this disease in the United States amounted to 100 million dollars It is estimated that 5 per cent of the cattle in the United States have Brucellosis and that there is a reduction of 22 per cent in milk production and 40 per cent in the calf crop of infected cows

The disease is quite infectious The chief mode of infection is through the digestive tract. The organisms usually enter by means of the feed and water From the digestive tract the organisms are taken into the blood and may localize in the genital organs or in the udder Infected animals discharge the bacteria at time of abortions, at normal calvings and for a period thereafter as long as there is any uterine discharge The organisms may also be present in the milk

The blood agglutination test is used to diagnose the disease The federal government, in cooperation with the various states has a program of Brucellosis eradication It is based on blood testing and slaughtering the reacting animals Requirements for accredited or certified herds are similar to tuberculosis requirements

Vaccination of animals against Brucellosis is being used as a control program Most states have adopted a calfhood vaccination program In this method, heifer calves between the ages of 4 and 9 months of age are vaccinated A low virulent strain (Strain 19) of the Brucella organism is used almost exclusively When a calf is vaccinated it will react for a time to the agglutination test The older the calf when vaccinated the longer time

* *Brucellosis* U S Livestock Sanitary Assoc 1949

that is required for it to return to a negative blood test The older calves seem to develop somewhat greater immunity than do the younger calves About 97 per cent of calves vaccinated between 4 and 9 months of age can be expected to be negative to the blood test by the time they are 30 months of age Many will be clear within a year after vaccination

When older animals are vaccinated they may carry a positive reaction indefinitely or throughout their lifetime The reaction cannot be differentiated by routine testing from that due to natural infection Adult vaccination with Strain 19 vaccine is not generally recommended, although it may have merit in some specific cases

Work has and is being done to develop new and improved vaccines, but they are still largely in the experimental stage and are not for general use

The calfhood vaccination program is a late development and is undergoing continual change and improvement Vaccinated heifers from clean herds are in strong demand

There are four plans for the control of Brucellosis, all of which depend upon the systematic testing of the herd and occasionally upon vaccination also They are as follows

Brucellosis Control Plans

PLAN 1 The herd is blood tested, and reacting animals, if any, are slaughtered

PLAN 2 The herd is blood tested with reacting animals, if any, slaughtered, and calfhood vaccination is initiated

PLAN 3 The herd is blood tested to determine the extent of the infection but the reactors are retained until vaccinated replacements are available (a maximum period of 4 years is suggested) Calfhood vaccination is practiced This plan permits the owner to remain in business and keep some valuable animals when otherwise it might be an economic hardship to slaughter all reactors Removal of animals from the herd, except for slaughter, is restricted

PLAN 4 Vaccinate the entire herd, including calves and adults This plan should be used only for herds needing emergency treatment for protection against a virulent infection, and it should

only be used as a last resort in Brucellosis control and almost never in a dairy herd.

Other Reproductive Diseases. Other diseases also cause abortions in cattle. In some, the causative organism locates in the uterus and causes the expulsion of the fetus. Others cause abortion indirectly by affecting the general condition of the animal.

Trichomoniasis is a disease of dairy cattle causing abortion and other breeding difficulties, such as failure to conceive and pyometra. It is caused by a protozoan, *Trichomonas fetus*, first reported in this country in 1932. The disease is spread by infected bulls during service and occasionally by close contact with infected cows. A bull may become infected by serving an infected cow.

A definite diagnosis of the disease can be made only by finding the causative organism by direct microscopic examination of material from the sex organs of the cow or bull. This disease may be extremely difficult to diagnose positively. A study of the breeding history of the herd and of individual animals in the herd may give an indication of the presence of the disease.

There is no specific treatment for the disease. Infected bulls should not be used. Some treatments are being tried for bulls. When the herd is known to be infected, artificial insemination should be practiced exclusively. Cows that abort may recover if given a period of sexual rest of about 3 months, as the organisms will not live longer than 3 months in the nonpregnant cow.

Vibrio fetus is a comma-shaped bacterium that may cause abortion in cattle. It interferes with the normal function and attachment of the placenta. The outbreaks seem to occur sporadically, causing considerable trouble, but with no evidence or history of means by which it gained entrance into the herd. After a time, during which it seems to run its course, it disappears as mysteriously as it gained entrance.

The diagnosis is based on the examination of the aborted fetus, for the organism itself. Abortions occur most frequently from the fourth to the sixth month. This disease has been found to be the cause of temporary sterility in many herds in cows that do not abort, and when the number of cows aborting in the herd is quite low. Means of spread of infection is not

entirely known Laboratory examination of aborted fetuses to find the organism or organisms causing the abortion, whether Brucellosis, trichomoniasis, vibriosis, or another is a procedure recommended in making early diagnosis and eliminating the trouble as early as possible

Mastitis. Mastitis is one of the most serious and costly diseases with which the dairy farmer has to contend The annual monetary loss, due to the loss of valuable cows, decreased milk production, and poor quality milk, is tremendous

There are two forms of the disease, the acute and the chronic The acute form is readily recognized, although it is much less common than the chronic It is recognized by the sudden development of a swollen quarter, which becomes hot and painful The secretion is much reduced and varies in consistency from a watery blood tinged fluid containing a few solid particles to a thick, yellow, ropy material Such cases are usually accompanied by a general reaction of the animal, such as loss of appetite, a rise in temperature, diarrhea, chills, and general weakness Such cases were formerly thought to be temporary and it was believed that recovery meant the end of the trouble The acute symptoms are often simply a flare up of the chronic form already present in the udder, and recovery from the acute form often means a return to the chronic

The chronic form is of much greater importance than the acute It is not uncommon, upon examination, to find the chronic form of the disease in one or more quarters of the udders of half the cows in a herd Because of the lack of easily recognized symptoms the owner is usually unaware of the extent of the disease

Causes of Mastitis Mastitis is an infectious type of disease, caused by any of several types of organisms which gain entrance into the udder through the teat canal The streptococcus type, especially *Streptococcus agalactiae* is by far the most important These organisms spread rapidly through the udder and through the herd but rarely, if ever, cause disease in man Although herds have been known to have become infected from the hands of an infected milker and then spread such diseases as septic sore throat and scarlet fever through consumption of the milk, but

this is very rare, and these types do not tend to spread in the herd

Next in importance to the streptococcus type is the *Staphylococcus* This causes some forms of the chronic type, but the staphylococci are not likely to persist in the udder as long as do the streptococci. Occasionally, coliform type and other types of organism may infect the udder

Many factors contribute to this disease, such as injuries to the udder or teats, drafts, cold, damp stalls, inadequate stall space, exposures, excessive vacuum on milking machines, leaving the milker teat cups on too long, sores on the teats, and lack of sufficient bedding. Although young cows often have the disease, older cows are more frequently infected.

DIAGNOSIS The acute cases are easily recognized, but diagnosis of the chronic form is more difficult. The chronic infection in the udder may result in some change in the composition of the milk even though the milk looks normal As a result of the infection, the amount of butterfat, lactose, casein and probably other elements in the milk, may decrease At the same time, the number of leucocytes, the salt content, the number of bacteria, and other products resulting from inflammation and bacterial activity are increased A change in the character of the udder tissue also occurs The normal secretory tissue is gradually replaced by nonsecretory scar tissue and the affected quarters lose their soft, pliable quality and hard areas appear

There are several tests for diagnosing the disease, but the most accurate requires laboratory facilities and workers with special training. Two are useful and can be carried out by the dairy man

(*a*) *Udder examination* The physical examination of the udder will detect areas of fibrosis, indicate unevenness of quarters and detect injuries

(*b*) *Strip cup* In this test, several streams of milk are drawn from each quarter into a cup with a cover of a fine-mesh wire screen or black cloth immediately before the cow is milked. The appearance of clots or flakes on the screen is evidence of mastitis. This test is always used in well managed herds It does not, however, detect infected cows that are not giving abnormal milk.

The most reliable test for mastitis is the microscopic examina

of the mılk from each quarter. Thıs examınatıon wıll show kınd of bacterıa present and the leucocyte count Other ; ınclude the Hotıs test, tests for lactose or chlorıde, and the n-thymol-blue test

REATMENT Preventıon ıs more ımportant than treatment ; cow should be protected from ınjury and exposure, by pro- ıng her from all the contrıbutory causes whıch have already n lısted It ıs wıse also to use sanıtary precautıons durıng kıng such as washıng the teats wıth a dısınfectant solutıon be- ; mılkıng, and mılkıng last all cows known to have the ease

The acute form may be allevıated by contınuous applıcatıons hot water applıed to the affected quarter, accompanıed by quent mılkıng The quarters affected should then be treated ındıcated for the chronıc form

The chronıc form can best be treated by the use of certaın of e new drugs and antıbıotıcs whıch are ınjected ınto the affected arter. The followıng have been used wıth good results penı- lın, streptomycın, aureomycın, gramıcıdın, bacıtracın, tyrothrı- ı, and varıous sulfonamıdes Treatment ıs most effectıve ıen admınıstered before the dısease becomes acute, sınce of urse ıt cannot restore scar tıssue to normal tıssue

The effect of the antıbıotıcs on the mılk supply has caused me problems ın daıry plants The concentratıon of these ın e mılk ınhıbıts the growth of acıd-producıng bacterıa for sev- al mılkıngs after treatment Thıs causes trouble ın the manu- cture of cheese, butter, buttermılk, and ın makıng starters or these reasons, ıt ıs now recommended that mılk from a eated cow should not be added to the salable mılk for a perıod f 72 hours Such mılk, ıf otherwıse normal, can safely be fed ɔ the calves durıng thıs perıod

Mılk Fever, Also Called Parturıent Paresıs or Parturient Hy- ocalcemia. Mılk fever ıs a dısease that usually occurs only after alvıng and then generally only ın the hıgh producıng anımals Mılk fever ıs rare ın first-calf heıfers and occurs most frequently n well fed cows It seems to be more common ın the hıgh test- ng breeds

SYMPTOMS The first symptom of the dısease ıs staggerıng, dullness of the eyes, and a fallıng temperature. The cow lıes

down and becomes paralyzed. When a state of coma occurs, she will lie on her brisket with her head turned back toward her side. Sometimes as the condition progresses, the cow will stretch out on her side with her head extended. When in this condition, the cow may contract mechanical pneumonia as a result of inhaling food material that is regurgitated or flows from the paunch while she lies in this position, or she may suffer extreme bloating. She should be propped up on her brisket to avoid this trouble. Usually, unless prompt relief is given, death results in a short time.

CAUSE OF MILK FEVER. Milk fever is caused by the lowering of the calcium salts of the blood. The supply of calcium in the blood may become low if calcium from the tissue reserves is not mobilized as rapidly as the udder takes it from the blood. The parathyroid hormone appears to be the responsible agent for regulating blood calcium. The reason for an insufficient hormone activity has not been determined.

TREATMENT. Milk fever may be cured by intravenously injecting 250 to 500 cubic centimeters of a 20 per cent solution of calcium gluconate. Sometimes a second or even a third injection may be necessary.

An older treatment in which the udder was inflated with air proved effective. Treatments were sometimes followed by udder infections due to unfiltered air and to the use of equipment that had not been cleaned and sterilized. The air in the udder builds up back pressure that stops milk secretion and the withdrawal of calcium from the blood. This process allows the blood to rebuild its calcium supply. Response after this treatment is not as rapid or regular as it is after the injection of calcium solutions. Medicine should never be given a cow by mouth when she has milk fever, as her throat is partially paralyzed and the medicine may go down the windpipe and cause pneumonia.

It is a recommended practice not to milk a cow completely dry for several milkings after calving. This will reduce the amount of milk secreted and consequently the amount of calcium taken from the blood. It has been observed that cows with caked udders at time of calving seldom have milk fever. This may be because of the fact that not all the milk can be removed from such udders.

Preventive measures generally have not proven successful However, studies at Ohio * and Virginia † have indicated that massive doses (10 million to 30 million units daily) of vitamin D in the form of irradiated yeast given 4 or 5 days before calving may reduce the incidence of milk fever

Acetonemia, Also Called Ketoses Acetonemia is a metabolic disturbance caused by an abnormal concentration of the ketone bodies in the blood, milk, and urine of affected animals These ketone bodies are the products of incomplete utilization of body fat, and the main ones are acetone, acetoacetic acid, and beta-hydroxy butyric acid The disease usually occurs within 6 weeks after calving and when cows have been exceptionally well fitted and then lose weight rapidly Reduced feed intake just before and after calving seems to be a contributing cause There seems to be a high incidence also in the early spring, when the cows are changed from barn feeding to pasture In certain sections of the country, probably because of soil deficiencies, the incidence of acetonemia is higher than in other areas

SYMPTOMS When present in its typical and uncomplicated form, acetonemia may cause the following symptoms abrupt drop in the milk flow, loss of appetite, rapid loss in weight, and drowsiness Other symptoms may include excitement, noted by circling in the stall or yard, pressing forward against the manger, and depraved appetite

DIAGNOSIS A test can be made of the urine for ketone bodies This test may not always indicate the disease, since any fasting animal will have ketone bodies in the urine

TREATMENT If a cow's appetite can be kept so that she will consume enough carbohydrates to avoid making unusual demands on the fat deposit of her body, she is less likely to have acetonemia If a cow goes off feed, however, or is limited in the amount of feed at the time that the milk flow is increasing rapidly, she will call on her reserves, which means an excessive use of body fat, with the possible formation of large quantities of ketone bodies, and, as a result, acetonemia

The intravenous injection of glucose solution is effective When the disease is associated with milk fever, the injection of

* *J Dairy Sci*, 34 198 (1951)

† *Proc Assoc Sou Agr Workers* (1952)

calcium gluconate is recommended. The feeding of molasses or corn sugar may be of value, as it not only provides a readily digestible energy but also stimulates the appetite so that the animal will eat more. The feeding of highly palatable feeds is urgent.

Reports * have shown recovery by treating cows with either cortisone or ACTH. Sodium propionate † has been found to be partially successful. The feeding or drenching with sodium acetate ‡ has been used with varying results in the treatment of this disease.

Bloat, Sometimes Called Hoven. Bloat is caused by an abnormal accumulation of gases in the paunch. This results in great distension of the organ with subsequent paralysis of its walls, the absorption of toxic gases, and pressure on vital organs, which, if not promptly relieved, may cause death. The gases formed in the rumen of bloated animals are also formed in the rumen of normal animals under normal feeding conditions, but with the latter the gases, as they are formed, are either belched or given off through the excretory organs. Bloat is more likely to occur when the animals are on legume pastures, such as the clovers and alfalfa. There does not seem to be complete agreement as to the conditions under which bloat will occur. Some years it gives little trouble, whereas another year under apparently the same conditions it will be troublesome. Some report more bloat in the morning, others more in the late evening, and still others more during the hottest part of the day. Some report more bloat when the dew is on the pasture, others feel that these conditions have no effect on bloat.

Excess gas production in the rumen is not the cause of bloat, per se, since the ruminant can normally belch more gas than is likely to be produced. The cause of the accumulation of gas is due to the animal's inability, under certain conditions, to belch the gas from the paunch. Evidence indicates that belching may result from coarse roughage in the diet, and that bloat on green legumes is due to a lack of scabrous material to stimulate nerve fibers in the wall of the rumen. For this reason, it is advisable

* *J. Dairy Sci.*, 35: 497.
† *Proc. Nutr. Council, AFMA* (December, 1952).
‡ *J. Dairy Sci.*, 35: 497.

to give animals a feed of hay before turning them on legume pasture

PREVENTION Certain precautionary measures will aid in reducing the number of cases of bloat caused by legume pastures Some of these are the following

1 Give the cattle a good feed of dry hay before turning them on a legume pasture This is very important, especially the first time they are on the pasture Do not turn them on the pasture when they are hungry.

2 Do not allow them on the pasture for a long period of time during the first few days Continue to barn feed until they become accustomed to the change

3 Do not seed legumes by themselves when they are to be used for pasture Have some grasses such as brome grass, orchard grass, or timothy in the mixture

4 Have some dry, coarse hay available for the cows, either in a rack or stack in the pasture or feed them before turning them out

5 Provide water in the pasture or nearby

TREATMENT In mild form, the gas may be released by placing a wooden stick or a bridle bit in the cow's mouth and placing the animal with its front feet higher than its rear feet With the cow in this position, the gas will have more opportunity to be expelled and the act of chewing on the stick or trying to get it out of its mouth may be effective in expelling the gas Another way to remove the gas is to insert a long rubber tube down the esophagus into the rumen, through which the gas may escape The animal may be drenched with various remedies in order to reduce the amount of fermentation Two to 4 ounces of turpentine or kerosene in 1 quart of water or milk, or ½ ounce of formalin in 1 quart of water, given as a drench, may inhibit further fermentation and allow the gas to escape normally Antiferments or debloating medicines have recently been developed and are effective treatments

Relieving severe cases of bloat consists of puncturing the rumen on the left side of the animal, using a trocar and cannula, in emergencies, a knife may be used The place to be tapped is the center of a triangle formed by the hipbone, the last rib, and the backbone This method should be used only as a last resort

The cannula should be allowed to remain in the wound until all the gas has passed off.

Foot Rot, Also Called Foul Foot and Foot Evil. Foot rot is an infectious disease generally appearing between the claws of cattle. Affected cows move around with difficulty, decrease severely in milk production and many may develop an ill-shaped hoof as a result of this trouble. Most dairy herds are troubled to a certain extent by this disease. Certain conditions, such as wet, muddy barnyards or pasture, and foot injuries as wire cuts and bruises are predisposing factors to infection. The disease spreads rapidly in muddy yards and when so established is difficult to eradicate. The infection may also enter the body through the digestive tract or by other routes. The first symptom is lameness which, together with the characteristic odor, is sufficient to show its presence.

Treatment. The first thing to do is to clean the affected part thoroughly, washing it with a strong solution of disinfectant and to keep the animal in a clean, dry place. Powdered copper sulfate, dusted over the affected part or dissolved to form a paste or a 5 per cent solution and then put on has proved satisfactory. If several cows are affected, a solution of formaldehyde or of copper sulfate can be made in which the animal can stand for several minutes every day. Intravenous injection of sulfapyridine or sulfamethazine or a combination of the two has been effective in its treatment when given in the early stages of the infection.

Hemorrhagic Septicemia. Hemorrhagic septicemia or shipping fever is a mixed bacterial infection causing various symptoms, including fever, chilling, coughing, discharge from the nose and eyes, weakness, and diarrhea. The disease is often complicated by pneumonia. It is associated with moving, fatigue, and exposure of animals of any age, but especially calves and young animals.

Proper feeding, care, and preventing exposure are the best methods for control. Cattle that are to be transported to sales or shows, with a probable exposure in transit, can be given some protection by the use of specific vaccines or serums. To be most effective, the vaccine should be given 10 days to 3 weeks [illegible] to allow time for the animal to develop

some immunity in its own body. If the serum is used, some resistance to infection is present immediately.

Pneumonia. Pneumonia is usually a secondary disease accompanying some other disease. As a primary disease, it usually follows chilling caused by exposure to cold winds and rains or to cold, drafty, damp quarters.

Pneumonia is characterized in the beginning by dullness, lack of appetite, high temperature, rapid and shallow respiration, and dilated nostrils. The muzzle is hot and dry, and the coat is rough and the skin dry. Diarrhea usually occurs, especially as the disease advances. In the treatment, good, hygenic surroundings, protected from drafts, winds, and rain should be provided. The calf should be blanketed and placed in a clean, well-ventilated stall.

Various sulfonamides and antibiotics have proved to be effective and their use usually result in rapid recovery if administered early and in proper dosage. Since the disease is encountered in many forms and stages, the proper treatment is a problem for a veterinarian.

Pinkeye. Pinkeye is a disease that causes irritation of the eye, with watering and pain. Advanced and complicated cases may show various symptoms, including blindness, which may be permanent. Animals of all ages, more especially calves and yearlings, are susceptible. Affected animals should be isolated and kept out of bright sunlight. Treatment with antibiotics is effective. The feeds should be high in carotene, as such trouble is sometimes aggravated by a lack of carotene and vitamin A.

Cowpox. Blisters containing a yellow fluid on the cow's teats are signs of cowpox. These blisters rupture, leaving raw sores or ulcers which are quite sensitive. This disease is not generally very serious and does not cause general symptoms in the cow, but the sore, painful teats do cause the milker a great deal of inconvenience at milking time. The hand milker can spread it from one cow to another, especially if there are scratches on the cow's teats, unless he washes and disinfects his hands between milkings. Various teat ointments, such as carbolized Vaseline or zinc ointment help to soften the affected spots and hasten healing.

Actinomycosis, or Lumpy Jaw. Lumpy jaw is caused by certain fungi which gain entrance to the body through the digestive tract, through openings in the skin, and perhaps by other routes. It appears in many parts of the body, although it is most commonly found on the jaw. If treatment is given in the early stages, some degree of success has been obtained by the administration of iodide of potassium. Some success, also, has been secured by treating with penicillin systemically or by injecting it into the center of the abscess 2 or 3 times a day, until the cure is effected.

Surgery may be necessary in extreme cases but it is not usually recommended as it tends to spread infection. When the disease is well advanced until the bone is affected, little can be done.

Johne's Disease (paratuberculosis). Johne's disease is a chronic infection caused by a bacillus. The intestines become inflamed which prevents proper assimilation of food and causes diarrhea and loss of weight, and eventually death.

The organism is carried in the feces of infected animals and from this may spread through pasture and other feed to other animals. There is no known cure for the disease. Where it is suspected the entire herd should be tested with johnin. The test is an intradermic test similar to the tuberculin test. The test and slaughter method is the only known program of eradication.

X Disease (Bovine Hyperkeratosis). X Disease has been reported in various parts of the United States since 1947. The symptoms of the disease are many. The skin is thickened, dry, and hard especially around the face and the folds of skin on the neck and shoulders. The tongue and gums become red and swollen. There is a loss of appetite and some salivation. The disease often results in death. It is not known how many animals may have only minor symptoms and recover, but with probable retarding of growth and development.

Research workers have been able to reproduce the disease by the oral administration of a lubricant containing a highly chlorinated naphthalene. Also, a wood preservative has been reported to cause the disease.

Some research work is under way in an effort to determine whether or not the causative factor interferes with the function of vitamin A in the body. No cure for the disease is known. As

a precaution, until more information is available, animals should not have access to products that might contain the causative agent.

Difficult Parturition. Cases of difficult parturition are comparatively few and it is best not to interfere with the delivery of the calf unless it is definitely apparent that assistance is needed The normal presentation is one in which the forefeet appear first, with the head lying on the forelegs When presentation occurs as it should, it is seldom that the cow will need help Sometimes deviations from the normal, such as the failure of one foreleg to appear, or the hindlegs appearing first, etc , occurs In such cases, the herdsmen can often render the necessary assistance In more complicated cases, a veterinarian should be called

Retained Afterbirth It occasionally happens that the afterbirth, or placenta, does not come away This is especially common after abortions and is associated with infections of the reproductive tract Unless the afterbirth is removed, serious complications may result If the afterbirth has not come by itself within 48 to 72 hours, it should be removed The removing of the afterbirth should not be attempted by anyone who is not familiar with the anatomy and normal functioning of the cow's uterus Improperly done, it can result disastrously for the cow's future breeding possibilities or even for her life

Teat Troubles. The teats of milking cows often become scratched or cut Various ointments and skin antiseptics will hasten the healing of these wounds Care should be taken to remove from the lots and pasture anything which might cause injury to the udder and teats of the cow

Deep wounds that enter the teat canal, leaky teats, closed teats, spider teats, and various teat injuries should receive the attention of a veterinarian Many of these may require surgical treatment if satisfactory results are to be secured These surgical procedures and the use of teat plugs, dilators, and tubes should be used with extreme caution to prevent the entrance of infection into the udder, causing mastitis Teat troubles are among the most difficult problems a veterinarian has to treat unless extreme care and cooperation on the part of the herdsman or owner are exercised at all times

Common Scours. Common scours is one of the ailments that occur most frequently in calves A frequent cause of scouring is overfeeding If the calves have not been overfed, the condition may have been caused by feeding from dirty pails, feeding cold and warm milk alternately, feeding sweet and sour milk alternately, feeding milk too rich in fat, irregular feeding, or unsanitary and damp pens The first symptom usually noted is staining on the tail of the calf, caused by semifluid and foul smelling feces, after which it can be noted that the calf is listless and has little appetite Prevention of this trouble is easier than its cure Care should be taken in getting the calves back on feed so that they will not come down with another attack Although common scours is not considered infectious, it is always a good practice to keep sick calves away from the other calves

White Scours White scours is an infectious disease that attacks calves at birth or during early life The symptoms are diarrhea, dullness, weakness and prostration, sunken eyes, short hurried breathing, and elevated temperature The discharges of the bowels are profuse, yellowish white, and very offensive in odor The disease may be fatal within a short time without proper treatment.

Prevention is the best means of combating white scours All cases should be isolated, the carcasses of the dead calves burned, and the stable thoroughly disinfected When the herd is small, the disease can usually be prevented by removing the dam to clean quarters a few days before the time of freshening and keeping her there for 4 or 5 days afterward Some degree of success has been obtained by injecting antiwhite scour serum into all calves immediately after birth This, however, must be done as soon as the calf is dropped, otherwise it is not successful Various sulfonamides and antibiotics have been used with varying degrees of success

Ringworm Ringworm is a fungus growth quite common in calves Besides detracting from their appearance, it affects the thrift of the animals The disease is characterized by ringlike spots on the skin, usually on the head, neck, shoulders or rump, where the hair has come out and scabs have formed

The scabs and crust should first be removed from the affected area with water and soap, using a stiff brush One treatment

consists of applying tincture of iodine to the spots. Several effective fungicides have been developed.

Lice. Two species of lice commonly affect cattle, especially young cattle. Their presence is indicated by rubbing, loss of hair, and eventually loss in weight. One of these species is a blood-sucking louse, the blue louse, and the other is a biting louse, the red louse. Lice spend their life cycle on the host. The female lays from 30 to 35 eggs when they are about 12 days old, and these eggs (nits) cling to the hair and hatch in from 11 to 18 days. The red lice are usually found on the side of the neck, withers, and tail head, but they may be found elsewhere. The blue lice attach themselves in patches on the side of the neck, brisket, back, inner surface of the thigh, and around the nose, eyes and ears.

Good herd management goes a long way in controlling lice. Well-fed animals seem to resist infection, and when infected they do not suffer as severely as poorly fed animals. The trouble may be controlled by spraying the affected animals with a mixture of methoxychlor and lindane, as recommended for the control of flies. Lindane should not be used for calves under 3 months of age. Rotenone powder is effective, also, and it can be applied in cold weather when spraying would not be advisable.

Other Diseases. There are many other diseases and ailments of dairy cattle. Some are quite common in their occurrence while others are not widespread or are newer diseases in many of the areas. Some diseases, including foot and mouth disease and anthrax, are of national concern because of their highly contagious nature and the recent outbreaks on this continent. Leptospirosis and anaplasmosis are diseases that are showing up in more herds than formerly.

FEDERAL AND STATE OFFICIALS

The Bureau of Animal Industry of the United States Department of Agriculture has many safeguards to prevent disease infections from coming into this country. In the event of outbreaks of certain diseases, this agency is charged with its control. There are also regulations affecting interstate shipment of livestock.

The various State Departments of Agriculture also are work-

ing on the prevention and control of livestock diseases There are regulations governing the importation of livestock into the state, as well as intrastate shipments Many of these departments have one or several diagnostic laboratories for helping veterinarians and farmers in diagnosing diseases Livestock farmers should acquaint themselves with federal and state regulations and facilities and make use of them in maintaining healthy herds

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27

Keeping Records on the Dairy Farm

NECESSITY FOR KEEPING RECORDS

A successful business establishment always has a system of keeping records of transactions. Business cannot be conducted efficiently without such methods. This is just as true of the dairy business as of any other. A dairyman who does not have a fairly accurate record of the amount of feed given to the cows in his herd, and of the amount of milk and butterfat which they produce, is certainly not conducting his business upon the most efficient basis.

The actual time required to keep such records is much less than might at first be expected. Their value is clearly seen when it is realized that the selection of the herd for improved production is based upon the results of records. Cows should be valued largely by the amount of milk and butterfat they produce. Other factors, such as regularity in breeding and ability to produce offspring of equal or greater producing power than the dam, should also be considered in placing a value on a cow. Unless accurate records are kept, the best cow in a herd is likely to have equal rank with the poorest, at least in the mind of the owner.

PRESERVATION OF PERMANENT RECORDS

One essential of records is that they be simple, though they should contain all necessary information. Many dairymen have become discouraged in the keeping of records because too complicated a system was inaugurated. As many records as possible should be final and not require copying. This is not possible with all forms of records, however.

There are three general methods of preserving records Individual conditions will determine which one is best suited to each case Records may be kept in any of the following ways (1) in books with permanent leaves, (2) in loose leaf books or files, and (3) in envelopes

There are advantages in using books with permanent leaves for some records, whereas the loose-leaf books, files, or envelopes are better for others For breeding records, the permanent leaf book has the advantage of being safer, as the separate pages cannot be lost, but it is cumbersome, as old records must be handled frequently and exposed to the danger of being lost if the whole book is lost. The loose leaf records, however, may be divided and only those records that are in use at a particular time need be kept at hand, the records that are used only for reference, such as those of cattle that have gone out of the herd, being put away for safe keeping The loose leaf records also have the advantage that all the data relating to an individual animal may be kept together so that when it is desired to get any information upon a certain cow all such information will be together in one book The files have the same advantages as the loose leaf book, but are not so easily carried around, nor are they so convenient to handle

In the envelope system, one envelope is provided for each cow, and in that envelope all records pertaining to the cow are kept This system is not as convenient as some of the others, but is often used for the filing of registration and advanced registry papers

KINDS OF RECORDS

Several kinds of records may be kept on the dairy farm. Some of them are more important to the purebred breeder than to the breeder of grade animals The record of production should be kept by all dairymen, however

The important records to be kept are as follows (1) production records, (2) feed records, (3) breeding records, (4) health records, and (5) growth and weight records

Production Records

If one is to know the production of individual cows, two facts must be ascertained, namely, the pounds of milk produced, and the percentage of fat in the milk, from which the pounds of butterfat can be calculated. It is important that both these items be known. However, if it is possible to ascertain but one of them, the pounds of milk is much the more important. The variation between individuals is from 2 to 5 times as great in milk yield as in fat percentage. It has been found that the milk yield usually bears a very close relationship to the butterfat yield. The high testing cows are not always the best cows. The mere fact that a cow has a high butterfat test in no way determines that she is a profitable cow. A high test along with high milk production insures a good cow, but the high test may just as readily be accompanied by a low milk yield, and if so the cow may be unprofitable. Within a herd there is but little relationship between the percentage of fat in the milk and the total milk yield. However, it is always wise, when possible, to secure a test on the cows along with the milk production. This is particularly true if the milk is being sold upon a butterfat basis, so that an exact account can be kept with each cow.

Reasons for Keeping Production Records. The first reason for keeping accurate production records is that such records show the production of the individual cows and this may enable the dairyman to discard those that are not paying a profit and to keep the calves from those of high production. As has been brought out before, there is a vast difference in the inherent ability of different cows to produce milk. One cow may produce 3 times as much milk or butterfat as another on one third to one half more feed. One cow may be causing the dairyman to lose as much money as another in the next stall is making for him. Cows that do not produce a profit are known as "boarder cows." Without records of production it is practically impossible to pick out the boarder cows from those that are yielding a good income. Milkers often believe that they can tell a good producer from a poor one without keeping records of production, but this has not proved to be true. Often those selected as the best turn out to

be the poorest, or vice versa. It is the production for the year that determines the value of a cow, not the quantity she may give for a few months. In order to determine her true value she must be fed and cared for throughout the entire year. Herd records show that cows that produce a moderate amount of milk persistently are usually more profitable than those that milk heavily for a few months but are dry for a large part of the year. It has been found that practically one-third of the cows in the ordinary herd are unprofitable. The milker is more likely to remember how easy a cow is to milk and how much she gives when she is fresh than how many months she will milk before going dry. It is necessary, then, to determine the actual amount of milk and butterfat that a cow produces during the year, as well as the actual amount of feed she consumes, in order to keep a complete financial balance with each cow.

Another reason for keeping a record of the milk production of the individual cow is in order to feed her properly. In a previous chapter it was stated that cows should be fed according to their production. In order to do this it is necessary to know what the individual cow is producing. Feeding by guess is always wasteful. By means of the milk sheet, a feed chart can easily be made up at intervals and the amount fed to each individual cow can be based upon her production.

The third reason why daily records of production should be kept is that they enable the herdsman to detect any abnormal condition, which may at any time occur in the herd. Often, a cow suddenly becomes indisposed. The milk sheet will tell this to the herdsman at a glance. Otherwise, the indisposition might go unnoticed until it developed into a serious sickness. The daily record also serves to call to the attention of the herdsman the ability of the different milkers and makes it possible to pick out those that are careless and indifferent.

A fourth reason for the use of a milk sheet is to keep up the interest of the milkers. The records of production often add considerable interest to the otherwise monotonous job of milking. The milkers and feeders are able to watch the variations on the milk sheet and will attempt to feed and milk in such a way that the production will increase, especially for those cows in which they are especially interested.

Equipment Necessary. The equipment needed for keeping daily production records is a standard milk scale, a milk sheet, and a Babcock milk-testing outfit Besides these, some form of permanent record of production should be provided

SCALES OR BALANCES A good scale to use for weighing milk is one in which the dial is divided into pounds and tenths This style of balance is provided with a pointer which can be adjusted to stand at zero when an ordinary milk pail is hung on it This enables the weight of the milk contained in the pail to be read directly The scale should be hung at some convenient place

MILK SHEET Close to where the scale is hung, a place for the milk sheet should be provided, so that, as soon as the milker ascertains the weight of the milk, he can easily put it down on the milk sheet The milk sheet should be fastened on a firm, smooth wall or board especially provided for the purpose Special holders for sheets have been devised, and are especially valuable if they are provided with a movable shield to protect the record from being soiled

Some sheets record the milk production for 1 week, but usually a monthly sheet is preferred This may vary considerably in detail, but Form A is a convenient one Form B shows a sheet arranged for 7 days This form is used more often in large or experimental herds where the record of production is desired at frequent intervals Form A, however, may have spaces for 10 days' totals, which can be further added so that the monthly total can easily be ascertained In the ordinary dairy, the monthly sheet without 10 days' total is common These sheets can be made in any size to accommodate from 5 to 30 cows The time required to weigh the milk and record it on the milk sheet need not exceed ½ minute * for each cow at each milking, and the value of the record obtained is worth that amount of time many times over

ADDING THE MILK SHEET By totaling the milk produced by each cow during the month, her monthly production may be secured This, however, where one does not have access to an adding machine, is a tedious task Under such circumstances, it has been found that fairly accurate results may be obtained by add

* *Farm Management*, Warren

FORM A

MONTHLY MILK SHEET

A FORM FOR KEEPING DAILY MILK RECORDS FOR A PERIOD OF ONE MONTH

Owner of herd, ______________ *Post Office* ______ *State,* ______________

Name or Number										Remarks
1	A.M.									
	P.M.									
2	A.M.									
	P.M.									
3	A.M.									
	P.M.									
4	A.M.									
	P.M.									
5	A.M.									
	P.M.									
6	A.M.									
	P.M.									
7	A.M.									
	P.M.									
8	A.M.									
	P.M.									
9	A.M.									
	P.M.									
10	A.M.									
	P.M.									
11	A.M.									
	P.M.									
12	A.M.									
24	A.M.									
	P.M.									
25	A.M.									
	P.M.									
26	A.M.									
	P.M.									
27	A.M.									
	P.M.									
28	A.M.									
	P.M.									
29	A.M.									
	P.M.									
30	A.M.									
	P.M.									
31	A.M.									
	P.M.									
Total pounds milk,										Prices of dairy products:
Total (per cent butterfat.)										
Total pounds butterfat										
Value whole milk, butterfat,										
Value skim milk,										
Total value of products,										

Average Daily Feed Record

Pounds,									Prices of feed:
Pounds,									
Pounds,									
Pounds,									
Pounds,									
Total cost of feed									
Income above cost of feed									

ing 3 days of the month, say the fifth, fifteenth, and twenty-fifth, dividing the total by 3, and multiplying this by the number of days in the month The days selected should always be well distributed throughout the month This will give a very accurate monthly yield Even when using this system, however, one

FORM B

WEEKLY MILK SHEETS

A FORM FOR KEEPING DAILY MILK RECORDS FOR A PERIOD OF ONE WEEK

Milk Record for Week Beginning ________ 19__ Milked by ________

Name or Number																	
Date		Lbs.	10th	Lbs.	10th	Lbs.	10th	Lbs.	10th	Lbs.	10th	Lbs.	10th	Lbs.	10th	Lbs.	10th
	A.M.																
	P.M.																
	A.M.																
	P.M.																
	A.M.																
	P.M.																
	A.M.																
	P.M.																
	A.M.																
	P.M.																
	A.M.																
	P.M.																
	A.M.																
	P.M.																
Total for week																	
Per cent, fat																	
Pounds, fat																	

Remarks ________

Week Beginning ________ 19__ Page ________

should weigh the milk for each milking because of the many other advantages which will accrue from this habit

OBTAINING THE PERCENTAGE OF FAT AND POUNDS OF FAT Samples for testing for butterfat should be taken at least once a month The sample should represent 24 hours of complete milking, and should be taken at fairly regular intervals

The essential feature in taking samples of milk for testing is to obtain milk which will be representative of the whole lot The milk should be thoroughly mixed by pouring from one vessel to

another several times, after which the sample should be taken immediately. The sample should be put in a bottle, and a small amount of preservative, such as corrosive sublimate or formalin, should be added when the samples cannot be tested at once.

After the samples have been tested by the Babcock test, the percentage of fat in the milk is known. The total number of

FORM C

FORM FOR KEEPING PERMANENT MILK AND BUTTERFAT PRODUCTION OF INDIVIDUAL COWS

Name ________ *No.* ____ *Herd No.* ________ *Breed* ________

Year															
For Month of	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat
January															
February															
March															
April															
May															
June															
July															
August															
September															
October															
November															
December															
January															
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April															
May															
June															
July															
August															
September															
October															
November															
December															
Yield per period															
Number of days in milk															
Record 365 days															
Age at start test															

pounds of milk that a certain cow has produced during a month, multiplied by the percentage of fat in the milk, will give the total number of pounds of butterfat which that cow has given during the month

THE PERMANENT RECORD After the total amounts of milk and butterfat for a month have been determined, they should be put in a permanent record of some kind. Form C gives an example of such a record It will be noted that this form is arranged so

that each cow has a page and that the record can be tabulated for each lactation period. After the lactation period is finished the record can be totaled—not only for the lactation period, but also for a yearly record. An individual may also use a regular dairy-herd-improvement association book for keeping such records. A page of such a book is shown in Form D. The man with a small herd, or the one who is just beginning, may use any simple notebook. The main thing is to have some permanent place to keep the records so that they may be kept in a neat and convenient form.

Method of Calculating Herd Averages. Several methods of calculating the herd average are now in use. There is need for a standardized method so that whenever the herd average is given it will always mean the same thing.

One method of determining the herd average is on the "cow-month" basis; that is, at the close of the year the number of months each cow is in the herd during that time is determined and totaled. The total months is then divided by 12. For example, if an individual owner has 10 cows in the herd for the entire 12 months, 1 cow for 8 months, 1 cow for 6 months, 2 cows for 5 months, 3 cows for 3 months, and 3 cows for 1 month, this gives a total of 156 cow-months. This 156 cow-months, divided by 12, gives 13, or the average number of cows in the herd for the year. The total production of the entire herd is then computed, and this figure, divided by 13, gives the average herd production for the year. This is the standard dairy-herd-improvement association method.

This method has the disadvantage that it permits a man, by buying and selling cows, to jockey his herd so that only heavy-milking cows are kept in the herd. It might be possible to secure a herd average that was greater than that of any individual cow in the herd. Of course such cases would be very few, and with the publication of the records one can detect such manipulation.

A second method commonly used is to count in the herd averages only such cows as have been in the herd for 10 months or more. The other cows are listed, but are not considered in the herd average. Table LXX illustrates the two methods.

BDI-DHIA-23
(Revised 1949)

Budget Bureau No. 40-R[illegible]
Approved expires [illegible]

FORM
LIFETIME RECORD

Registration name ____________ Registration No ______

Check if cow is progeny of artificial insemination

Breed ____________ Date of birth ____________ 19__

Sire used ______

Date fresh before testing year ____________ 19__ Date bred before testing year ____________ 19__

Testing period from ___ 19__ to ___ 19__	Days on test	Days in milk	[illegible]	Milk produced (pounds)		Average test (%)	Butterfat (pounds)	Value of product	Concentrates fed (pounds)	Cost of concentrates	Total cost of feed	Value of product over feed cost	Remarks
				Daily	Monthly								
Production since last fresh								$ $		$ $	$ $	$ $	Weight ____ Condition ____
to													
to													
Total to date													
to													
Total to date													
to													
Total to date													
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Total to date													
to													
Total to date													
to													
Total to date													
to													
Total or year													

NOTE TO SUPERVISOR.

The association Supervisor shall set up and enter in the herd record book this Lifetime Record of Individual Cow for each cow as she enters the milking herd. All copies of this form (BDI DHIA-23) *shall remain* in the possession of the Supervisor until he has filled out the headings and entered the form in the herd record book. *No blank forms shall be entered in the herd book.* Each form must be signed by the Supervisor to authenticate the entry

I CERTIFY that I have filled in the headings for this Lifetime Record of Individual Cow form and that the form was entered in the owner's herd book on ____________ 19__ The data given in the headings were verified by the owner and are correct to my best knowledge and belief.

____
(Signature of Supervisor)

Date fresh	Weight [illegible]

In this herd there were 7 cows in the herd for 12 months, 2 cows for 11 months, 1 cow for 10, 1 for 8, 1 for 6, 1 for 5, 1 for 3, and 1 for 1 month, or an average of 11 6 cows in the herd for 12 months The average production of these 11 6 cows was 9298.3 pounds of milk and 338 8 pounds of butterfat When the method

D
OF INDIVIDUAL COW

Page No. ______

______ Barn name ______________________________ Eartag No ______

☐ Sire ______________________________ *Eartag or* Registration No ______

______ Dam ______________________________ Eartag or Registration No ______

Testing period from ______, 19__ to ______, 19__	Days on test	Days in milk	Number days milked 3 times a day	Milk produced (pounds) Daily	Milk produced (pounds) Monthly	Average test (%)	Butterfat (pounds)	Value of products	Concentrates fed monthly (pounds)	Cost of concentrates	Total cost of feed	Value of product over feed cost (circle negative)	Remarks: Date freshened, calved, dry, aborted, sick, sold, etc. When 305-day record ends, etc.
Production since last fresh								$ ¢		$ ¢	$ ¢	$ ¢	Weight ______ [illegible] ______
to													
to													
Total to date													
to													
Total to date													
to													
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Total to date													
to													
Total to date													
to													
Total for year													

LACTATION PRODUCTION SUMMARY

The Supervisor shall report all 305-day lactation records to State Agricultural College on Form BDI 718

Age Year/Month	Days in milk	Number days milked 3 times a day	Total Production Milk (lb.)	Total Production Test (%)	Total Production B'fat (lb.)	First 305 Days Milk (lb.)	First 305 Days B fat (lb.)	305-Day Mature Equivalent Record Milk (lb.)	305-Day Mature Equivalent Record B fat (lb.)	Date reported on 718	Supervisor's initial when record is reported

by which the cows were in for 10 months or more was considered, there were 10 cows which had an average production of 9084.7 pounds of milk 336.2 pounds of butterfat. This method is used by some of the breed associations for calculating herd-improvement registry records.

TABLE LXX

CALCULATING THE HERD AVERAGE OF A HERD OF DAIRY COWS

Number of Cow	Days in Herd	Production of Milk, pounds	Production of Butterfat, pounds
1	365	10,217	408 8
2	365	10,069	357 9
3	365	6,452	257 7
4	365	7,726	307 9
5	365	8,612	294 8
6	365	9,027	296 7
7	365	11,199	439 1
8	335	11,758	415 9
9	325	9,468	345 7
10	305	6,319	237 4
Average of 10 cows in herd 305 or more days		9,084 7	336 2
11	240	5 367	217 6
12	180	3,449	101 4
13	150	4,008	110 2
14	92	3,210	102 0
15	30	980	37 3
Average of 139 cow months, or 11 6 cows per year		9,298 3	338 8

Feeding Records

To know how much profit a cow is making, it is necessary to know not only the production of the cow but also the amount of feed that she has consumed It is also necessary, especially in large herds, to have some form on which to put down the amount of feed that each cow should receive It is almost impossible for any individual to remember the amount of feed that should be given to each individual cow Usually, such a record should be changed at weekly intervals but sometimes it is arranged to run for 10 days or even 2 weeks Form E is one that has been used successfully This should be filled out according to the production of the individual cows and should be fastened to the feed

cart or near the feed bin The amount of grain given on the sheet should be carefully weighed at each feeding The rough age need not be weighed at each feeding but should be weighed at least once a month so that some idea of the amount will be obtained

FORM E

A BIMONTHLY FEED SHEET

Number of Cow	Date						19	
	Grain Ration No. ______		______ Hay		Silage		Other Feed	
	A.M.	P.M.	A.M	P.M.	A.M.	P.M.	A.M.	P.M

It is a good plan to number each definite grain mixture that has been fed to the herd A permanent record of these mixtures should then be kept so that the number of the mix may be put on the feed sheet In this way a definite record will always be kept

At the end of the month the amount of feed consumed may be totaled and put in a permanent record as shown in Form F Such records are sometimes kept in the regular dairy herd improve ment association book along with the milk records as shown in Form D At the end of the year the total cost of the feed which each individual cow has consumed can easily be calculated

Calf feeding requires a somewhat different form, since calves are fed whole milk, skim milk, grain, and hay. These can easily be made to conform to the conditions

FORM F

A PERMANENT FEED RECORD BLANK

Name ______________ No. ______ Herd No. ______________ Breed ______________

Month	Weight, Lbs.	Height, C.M.	Whole Milk, Lbs.	Skim Milk, Lbs.	Ration No.	Grain, Lbs.	Hay Lbs.	Silage, Lbs.	Other Lbs.	Pasture Days	Weight, Lbs.	Height, C.M.	Ration No.	Grain Lbs.	Hay Lbs.	Silage Lbs.	Other Lbs.	Pasture Days	Weight, Lbs.	Height, C.M.	Ration No.	Grain Lbs.	Hay Lbs.	Silage, Lbs.	Other Lbs.	Pasture Days
January																										
February																										
March																										
April																										
May																										
June																										
July																										
August																										
September																										
October																										
November																										
December																										
Total																										
January																										
February																										
March																										
April																										
May																										
June																										
July																										
August																										
September																										
October																										
November																										
December																										
Total																										

Breeding Records

Every cow should be given several weeks of rest before freshening, in order that she may be in shape for her best production before the next lactation Unless the exact date that each cow is due is known, some cows will be milked too long and others will be turned dry too soon It is also important to know the exact date of freshening so that the cow may be fed and cared for properly before and at the time of freshening. It is very important, then, that a breeding record of some sort be kept.

Since the herdsman does not always keep the books, it is sometimes necessary to have him report in order to get the necessary information on record His report should be simple but complete.

FORM G

A FORM FOR HERDSMAN REPORT

Date ______________, 195__

Gallons of milk shipped ______________________________

Feed Ground and Mixed **Milk Fed to Calves**

Mixture	Amount		Lbs	Number Calves Fed
________	________	Whole Milk	________	________
________	________	Skim Milk	________	________
________	________			

Cows in Heat

________	________	________
________	________	________

Breeding Record

Name	No	Sire Used	Artificial
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

Calving Record

Name of Cow	Sex of Calf	Weight of Calf	Herd Number	Normal Calving
________	________	________	________	________
________	________	________	________	________
________	________	________	________	________

Animals Treated

Name	Diagnosis	Treatment
________	________	________
________	________	________

Animals Sold

Name	Purchaser
________	________
________	________

Remarks ______________________________

____

Signed ______________________
Herdsman

Form G is one that can be used successfully The herdsman should put down at once the date, the cow bred, and the bull to which she has been bred This report should then be kept in a safe place until it can be entered in a permanent record

FORM H

FORM FOR KEEPING BREEDING RECORD OF THE HERD

Name ________ H.B. No. ________ Herd No. ________ Born ________

Sire ________ H.B. No. ________ Color ________

Dam ________ H.B. No. ________ Sex ________

Bred by ________ P.O ________ Breed ________

Date Bred	Sire	No.	Date Due 283 Days	Date Born	Weight at Birth	Sex	Name of Offspring	No.	Disposition

A satisfactory method is to have the herdsman's report forms bound in pads containing 62 sheets Alternate sheets may be perforated and carbon sheets used to make duplicate copies One copy may be kept at the barn and the other taken to the office or house for transfer to permanent records

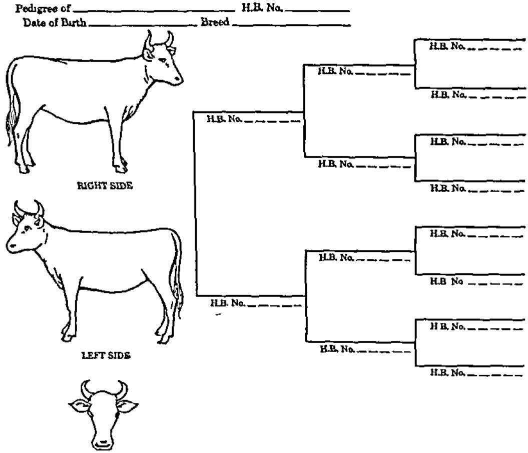
Form H is for the permanent record This form also has a place for the date of birth of the calf its sex weight, name and disposal The reverse side of the sheet can be provided with pedigree and identification marks to be used especially in pure

bred herds. This is shown in Form I. It is well to put in the breeding record each breeding date so that it can be seen when a cow is a slow breeder or when she becomes sterile.

This form of record, though important with grades, is almost

FORM I

PEDIGREE BLANK FOR HERD BOOK


Pedigree of ______ H.B. No. ______
Date of Birth ______ Breed ______

RIGHT SIDE

LEFT SIDE

H.B. No. ______ (×14)

necessary where purebreds are kept, as breed associations require the date on which the animal was bred, when registering it. As soon as a purebred calf is born, it is necessary to take the requisite steps to have it registered.

Health Records

It is often desirable to have a record of the health of the cows in the herd. This may be included in the herdsman's report and can become a part of the permanent record, as shown in Form J.

This includes a place for the tuberculosis test, the abortion test, and the general health Often, by a study of the health record of an animal, the reason for an unexpected result may be found.

FORM J

FORM FOR KEEPING A HEALTH RECORD OF THE INDIVIDUAL COW

Name ______________ No. ______ Herd No. ______ Breed ______

Tuberculosis Tests		General Health				
Date	Results	Date	Disease	Treatment	Duration	Effect
Brucellosis Tests						
Date	Results					

Growth and Weight Record

It is often advantageous especially with young animals, to keep a record of growth. This may consist of the weight of the animal or its height at withers or both. By this means one can tell whether an animal is growing normally With mature animals, the weight is of more importance If the animal is below weight, she can be fed so that she will return to normal. The best place to keep such a record is with the feed record, as shown in

Form F. Such records are essential in research work at experiment stations.

Inventory

Of all the records kept on the farm the inventory is the most valuable from the standpoint of keeping posted concerning the profits In the case of fire or loss in any other way of animals or apparatus, an inventory is often of great assistance. The inventory, together with the bank balances at the beginning and end of any period, is sufficient information from which to calculate the profits

For the inventory, a sheet with the items at the left side of the paper and several columns at the right is a good form Opposite each item is placed the number or quantity of times, and in the first column, its value The different columns are used for consecutive years Such a sheet shows at a glance the relative value of each item year by year.

Securing Poduction Records through Organizations

Production records are a necessity in herds where improvement is desired The breeding of dairy animals is dependent upon a knowledge of the production of the cows in the herd There are three common kinds of records, namely, the dairy herd improvement association, the advanced registry, and the herd improvement registry The first is used by breeders of grade and purebred herds The other two methods are conducted by the various breed associations and are used only by purebred breeders

Dairy Herd Improvement Association

Although the individual dairyman, by using the method outlined in the previous part of this chapter, can successfully keep production records on his own herd, this has not been a general practice, because on most dairy farms other work interferes with systematic and regular keeping of records In certain seasons of the year, especially during harvest, the testing is very

likely to be neglected and the work will go undone Further more the testing and the keeping of records entail a considerable amount of calculation and usually it will be put off until it be comes so great a task that it is never done For these reasons many dairymen prefer to have the work done for them, and therefore the dairy herd improvement associations have been developed

History of Cooperative Cow Testing The first cow testing association was organized in 1895 in Denmark where the program rapidly grew in popularity It spread throughout Den mark and other northern European countries until hundreds of such associations were formed It has been stated that these associations more than anything else are responsible for the rapid development of dairying and the improvement of the dairy cows in these countries

The first cooperative cow testing association in this country was started in Fremont Michigan in 1905 Helmer Rabild was largely instrumental in getting this association started and was its first tester The number of these associations later renamed dairy herd improvement associations has grown quite rapidly and in 1952 there were 2109 associations in the United States These associations were made up of 1 166,297 cows in 40 105 herds

Method of Organization The dairy herd improvement association as ordinarily conducted in this country is an organization of about twenty six dairymen who cooperatively employ a trained man to keep a milk production record of their cows and to test them for production of butterfat As a supervisor can ordinarily supervise only one herd a day the twenty six dairy herds furnish employment for each working day in the month

The cost of conducting such tests varies considerably In some places the cost is based upon the number of cows that a man has to test in others it is on a per diem basis The dairy man usually furnishes room and board for the supervisor while he is at the farm

The Supervisor and His Duties The man employed to make the tests is called the supervisor of the association Upon his per sonality and ability the success of the association largely de pends He should be a man who is congenial and trustworthy

he should know how to compute the cheapest and best rations for a particular locality. He must know how to test accurately for butterfat and be able to keep correct records. Above all, he must be industrious, accurate, and neat. The job is not an easy one, if it is well done. A good supervisor will do more than simply give a man a record on the cows in his herd.

Routine of Supervisor. The supervisor arrives at the farm, usually before the evening milking. He weighs the grain and the roughage given to each cow and also the milk produced by each. These weights are recorded, and a sample of milk from each individual cow is taken and put away until the following morning. The next morning he again weighs the feed and milk, and takes another sample of milk. These two samples are combined and are tested for butterfat. The data are then recorded, and the record of production for the month is calculated for each cow, this one day being used as the average. This is recorded in the dairy-herd-improvement association's book furnished by the Bureau of Dairying, United States Department of Agriculture which contains a page for each cow. The supervisor makes suggestions for the improvement of the feeding of the herd and gives any other assistance that seems advisable as a result of his observations.

With the record of production and feed for one day repeated each month, the supervisor at the end of the year can furnish much information about each cow. The amount of milk and fat produced during the year, the amount of feed eaten, its cost, and also the returns from each animal are computed, as well as the cost of producing 100 pounds of milk, the return for each dollar's worth of feed, and the profit or loss above feed cost.

Number of Cows Tested. Although this method of testing is being adopted quite rapidly, yet only a small percentage of the cows in the country are being tested. Less than 5 per cent of the milk cows in the United States are now under test. In California the percentage is as high as 22, but in many of the states less than 2 per cent are being tested. About 12 per cent of all herds of 15 cows or more in the United States are now being tested.

Value of Cooperative Testing. Besides the great importance of knowing the production of each cow, the richness of her milk,

and the amount of feed she eats to produce it, there are a number of other reasons why dairymen should cooperate. In general, the best herds and the most prosperous dairies are in localities where the farmers have cooperated and where there are many breeders of good animals in the same community. The dairy herd improvement association enables neighbors to solve their problems and difficulties together. Where there is such an association, it is easier to select cows for what they are worth than in communities where records are not kept.

The following are main reasons why dairy herd improvement associations are valuable.

1. The "boarder" or unprofitable cow can be located and discarded. After studying many thousand records, the United States Department of Agriculture Bureau of Dairying has found that about one-third of all the cows in the United States are kept at a loss, another one-third just about pay for their keep, and the other one-third give a profit to their owners. If the third that is being kept at a loss could be discarded, the dairymen would greatly benefit.

2. Calves for replacement can be kept from the highest-producing cows. Unless a dairyman has production records on his cows he does not have a sound basis for selecting herd replacements. It is next to impossible, by looking at a cow, to tell what her production will be. Improvement of the herd depends upon keeping calves from the best cows in the herd.

3. Bulls can be proved. One of the greatest benefits from testing continuously is the proving of bulls. The records are sent to the Bureau of Dairying where they are tabulated, and in this way many bulls are proved. In 1950, 2817 bulls were proved by this method. Of course, many of these bulls were dead before being proved, but a system has been devised whereby the animals in the herds of the association members are given an eartag with a number, so that they can be identified at any time. The records of cows are reported as soon as made, so that the time required for the proving of sires will be much lessened.

4. The value of the herd will be increased. Cows with records invariably sell for a better price than those without records, be-

cause a buyer can know just about what to expect from the cows he buys

5 The herds will improve Men in dairy herd improvement associations invariably will feed their herds a little better and give them better care if they become interested in records This is shown by the fact that cows in dairy herd-improvement association work produce almost twice as much as the average cow in the United States

6 Community interest in better livestock is aroused Often, a dairy herd improvement association will result in a widespread interest in livestock, which may bring about improvement in many ways

Advanced Registry Testing

When the breed associations were started, the fact that a pure bred animal was registered was considered as evidence of superiority However, after several years of registering in this manner, it became apparent that the law of variation operated in purebred herds just as it did in grade or scrub herds The result was that the associations registered many inferior animals Also, at that time many large private records were reported by various breeders, but the word of the breeders was the only check on their accuracy For these reasons the various breed associations evolved a production testing program based upon the individual merits of the cow and on making the records official by having them supervised by some disinterested party

The first of these systems in this country was established by the Holstein Friesian Association of America in 1885 The other breed associations, seeing its possibilities, soon organized systems of their own the American Guernsey Cattle Club in 1901, the Ayrshire Breeders' Association in 1902, and the American Jersey Cattle Club in 1903 The last named association called their registry the Register of Merit, the others are called Advanced Registry Later, the Brown Swiss Breeders' Association organized a Register of Production, the Milking Shorthorn Breeders' Society, a Record of Merit, and the Red Polled and Dutch Belted, an Advanced Register These are all conducted in very much the same manner and differ only in name Be

cause of the cost of making these tests, the growth of such associations was naturally slow in the beginning, but after the public was educated to the fact that milk production and butterfat production are inherited characteristics, such work became popular Today it is difficult to sell purebred cattle for the better prices unless they or their ancestry have been recorded in the Advanced Registry or Herd Improvement test, or are tested in a dairy herd improvement association

Kinds of Tests Two general terms are applied to Advanced Registry tests These terms, however, are not used with the same meaning by different associations In all except the Hol stein Friesian Association, the term "official" is used when a test has been checked or supervised by an official appointed for that purpose With the Holstein Friesian Association, however, only the records made while the supervisor is present are called offi cial, those tests made at intervals being known as semiofficial.

Tests are also classified by the length of time for which they continue For instance, there have been 7 day, 30 day, 305-day, and yearly tests The 305 day tests and some of the yearly tests have a calving requirement. The short time tests are no longer conducted The 305 day test with a calf within 14 months is the most popular at the present time

With the long time tests, the supervised period is for a day each month, preceded by a preliminary milking for observation to see that the cow is milked dry and to establish a starting point. The fat test during this period forms the basis for calculating the fat production, and the weights of milk are used to check the weights obtained by the owner The owner's weights are used and should be in reasonable agreement with the weights reported by the supervisor

The Supervision of Tests. In order to make the tests of the various associations of equal value to the public, all tests within the state are supervised by the state agricultural college If a breeder desires to test he should first get in touch with the breed association and then with the dairy department of the state agricultural college, who will send a tester to supervise the test.

Advantages of Advanced Registry Testing The advantages of Advanced Registry testing are much the same as for other

forms of testing as already discussed It has the further advantage, however, that the records of the individual cow are published in breed journals and in herd books which may be made available to all breeders

Disadvantages of Advanced Registry Testing One of the chief disadvantages of Advanced Registry testing is that it encourages individual records rather than herd averages Some purebred breeders put only their best cows on test They then give these the best of care and attention in order to get the largest possible production The poorer cows in the herd are not tested By this means the breeder sometimes builds up a reputation for his herd with the records of a few outstanding animals A certain bull may also gain a reputation with a few high producing daughters, though perhaps many of his daughters have not been tested, and if tested could not meet the Advanced Registry requirements

It encourages the use of selected records A selected record, one high record made under excellent conditions, often tells little as to the real producing ability of an animal

Another disadvantage of Advanced Registry testing is that often, in order to secure the largest production possible from individual cows, they are not bred until late in the period of lactation In many cases the result is that the cow cannot be bred successfully again, and, hence, is lost to the breed This practice has been lessened by the encouragement of the 305 day test with a calving requirement Advanced registry is an expensive method of testing The smaller breeders could not afford to test, and when they did test they could not afford to give the animals the care and treatment which was possible by wealthy breeders For these reasons, Advanced Registry testing did not reach as many people as it should The expense was increased in many cases by the overzealous supervision required to prevent fraud This objection has been lessened by the reduction of the length of the test from 2 days with preliminary milking to 1 day with preliminary milking, and to the bimonthly testing in some cases

Relation between Age and Fat Production in Advanced Registry Records It has long been observed that milk and butterfat production gradually increase as the dairy cow matures

and then gradually decrease with the onset of old age. A heifer is expected to increase in production with each succeeding lactation until she reaches maturity. The breeds do not seem to increase at quite the same rate, nor do they reach maturity at the same age.

TABLE LXXI

AGE-CONVERSION FACTORS USED BY THE BREED ASSOCIATIONS

Age, Years	Factor: Ayrshire *	Brown Swiss *	Guernsey †	Holstein	Jersey *
Under 2	1.338	1.568			1.36
Jr. 2	1.250	1.469	1.25	1.25	1.26
Sr. 2	1.176	1.343	1.20	1.20	1.19
Jr. 3	1.127	1.241	1.16	1.15	1.13
Sr. 3	1.082	1.166	1.10	1.10	1.08
Jr. 4	1.049	1.112	1.07	1.07	1.05
Sr. 4	1.028	1.070	1.03	1.05	1.03
5	1.007	1.028	1.00	1.02	1.01
6	1.000	1.006		1.00	1.00
7	1.000	1.000		1.00	1.01
8	1.012	1.000		1.00	1.04
9	1.024	1.012		1.00	1.08
10	1.046	1.048		1.03	1.12
11 or over	1.070 ‡	1.096 ‡		1.05	

* Mid point figures for 6 months used

† Based on average milk production by classes for 5 year period 1943–48

‡ Factors continue to increase above 11 years

Table LXXI gives the age conversion factors that are used by the different breed associations for converting records made at various ages to a mature equivalent basis. Factors used by the Bureau of Dairy Industry for proving sires are given in Chapter 22.

Herd Improvement Registry

In order to overcome some of the disadvantages of the Advanced Registry test and to increase the number of animals tested, the Ayrshire Breeders' Association started, in 1925, a test known as the Herd Test, which gives promise of being a success-

ful means of raising the herd averages. The Hoistein-Friesian Association adopted a similar test in 1927, called the Herd Improvement Registry, and the other breed associations soon followed.

The primary purpose of the Herd Test or Herd Improvement Registry is to obtain records on the entire herd for the purpose of making definite herd improvement. It permits of the testing of more cattle at a lower cost. It also permits the closer culling of herds and the early identification of superior sires. It gives an official herd average in all associations, except the Guernsey and the Brown Swiss.

Method of Test. The test is conducted by the same supervisors who conduct the Advanced Registry test, and in most states the supervisors employed by the Dairy Herd Improvement Association are also permitted to do the testing. The work is supervised by the state agricultural colleges, in the same way as Advanced Registry testing. The length of test is 1 day per month without preliminary milking, or, in some of the breeds, 1 day every other month with a preliminary milking is permitted. All purebred cows in the herd must be tested, and they can be milked either 2 or 3 times per day. Composite milk samples are used, the same as in dairy herd improvement associations.

Reports are sent monthly to the breed associations and at the end of the year a full report is given to the owner. This includes the production of each cow in the herd and the herd average, as computed by the methods described previously. The Guernsey and Brown Swiss Associations give only the production of the cows and not the herd average. From these data the production of the daughters of individual sires can be computed.

This type of test has become a popular type of testing among purebred breeders. More animals are being tested than ever before. It has given impetus to the proving of sires and to the increased production of the herds. It has resulted in great improvement in the dairy breeds.

REFERENCES FOR FURTHER STUDY

1. McDowell, Dairy Herd Improvement Associations and Stories the Records Tell, *U.S.D.A. Farmers' Bul.* 1604 (1929).

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TABLE LXXI

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Under 2	1 338	1 568			1 36
Jr 2	1 250	1 469	1 25	1 25	1 26
Sr. 2	1 176	1 343	1 20	1 20	1 19
Jr 3	1 127	1 241	1 16	1 15	1 13
Sr. 3	1 082	1 166	1 10	1 10	1 08
Jr. 4	1 049	1 112	1 07	1 07	1 05
Sr 4	1 028	1 070	1 03	1 05	1 03
5	1 007	1 028	1 00	1 02	1 01
6	1 000	1 006		1 00	1 00
7	1 000	1 000		1 00	1 01
8	1 012	1 000		1 00	1 04
9	1 024	1 012		1 00	1 08
10	1 046	1 048		1 03	1 12
11 or over	1 070 ‡	1 096 ‡		1 05	

* Mid point figures for 6 months used

† Based on average milk production by classes for 5 year period 1943–48

‡ Factors continue to increase above 11 years

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This type of test has become a popular type of testing among purebred breeders More animals are being tested than ever before It has given impetus to the proving of sires and to the increased production of the herds It has resulted in great improvement in the dairy breeds

REFERENCES FOR FURTHER STUDY

1 McDowell, Dairy Herd Improvement Associations and Stories the Records Tell, *U S D A Farmers Bul* 1604 (1929)

2 Gifford, The Reliability of Bi-monthly Tests, *J Dairy Sci*, 13 81
3 McIntyre, Correlation Between Annual Butterfat Production and Annual Feed Costs of Dairy Cows Under Farm Conditions, *J Dairy Sci*, 14 73 (1931)
4 Gaines and Palfrey, Length of Calving Intervals and Average Milk Yields, *J Dairy Sci*, 14 294 (1931)
5 Dairy Herd Improvement Association Supervisor's Manual, *U S D A Bur Dairy Ind*
6 *Unified Rules for Official Testing*, Purebred Dairy Cattle Assoc
7 Production testing herd books of each of the breed registry associations

28

Programs of the Breed Registry Associations

All recognized breeds have a breed registry association that looks after the interest of the breed they represent. The members of these associations are the owners of cattle of the breed, who have joined the association and paid their fees. To become a member a breeder must be approved by other members or business men. This membership gives the member a voice in the operation of the association, and permits him to register and transfer his animals at a reduced fee. Table LXXII gives the

TABLE LXXII

Breed Association Membership, Fee, and Number of Animals Registered in 1950

Breed	Number of Association Members (1950)	Life-Membership Fee	Number of Animals Registered (1950)
Ayrshire	8,167	$25	24,236
Brown Swiss	2,746	25	22,702
Guernsey	3,956	50	94,901
Holstein-Friesian	41,110	25	184,246
Jersey	3,610	50	70,110

number of members, the life-membership fee, and the number of animals registered during 1950 for the five dairy breeds associations.

Each association holds an annual meeting where the members have the opportunity and responsibility of helping to determine the policies of the association. Members of the Holstein-Friesian Association are represented at the annual meeting by delegates from each state. These delegates are elected by the members in

the state, and the number is based on the number of members in the state In the other associations, the member may attend, or, if he is not able to attend, he may be represented by proxy through some member in attendance

At the annual meeting, a board of directors is elected and this board of directors operates the association through an executive secretary and his staff The associations must have an adequate building to keep the records and house the staff This building must be equipped with fireproof vaults so that in case of fire the valuable records would be preserved The following are the official names and the locations of the various associations, with the name of the executive secretaries

The American Guernsey Cattle Club, Peterborough, New Hampshire, Robert D Stewart, Secretary

The American Jersey Cattle Club, Columbus, Ohio, James Cavanaugh, Executive Secretary

The Ayrshire Breeders Association, Brandon, Vermont, David Gibson, Jr , Secretary

The Brown Swiss Cattle Breeders Association, Beloit, Wisconsin, Fred S Idtse, Secretary

The Holstein Friesian Association of America, Brattleboro, Vermont, Robert Rumler, Executive Secretary

Purpose of the Breed Association. The purposes of the breed associations are (*a*) to preserve the purity of the breed, (*b*) to improve the breed in type and in production, and (*c*) to advertise and promote the breed. Although these purposes of the association are fairly specific there is some overlapping and it may be difficult to know where one purpose begins and another leaves off For example if the production and type of a breed are increased these factors in themselves will go a long way toward advertising and promoting the breed.

(a) Preserving the Purity of the Breed Preserving the purity of the breed was the prime object in the initial organization of the associations In fact, during the early years it was about the only thing that was done Rules and regulations on registration of purebred animals were formulated, and today the five dairy breed associations have quite similar requirements for the registration of animals Color markings or photographs are required for identification by the Ayrshire, Guernsey, and Hol

stein-Friesian Associations, whereas the Jersey and Brown Swiss Associations require that all animals have a tattoo in the ear for identification. The Brown Swiss and Holstein-Friesian Associations have certain color marking requirements for an animal to be eligible for registration. The application for registry must be filled out by the breeder or his representative and mailed to the association office.

The association then issues a registry certificate for each animal accepted. These certificates give the name of the animal, its registration number, its birth date, the name of the breeder and owner, its identification, its sire and dam, and some of the associations give additional information. A registration certificate is sent to the owner of the animal.

Transfer of Ownership. When a registered animal is sold to another breeder, the change of ownership must be recorded with the breed association in order to show proper title to the new owner. An application for transfer is filled out by the seller, which, together with the registration certificate, is sent to the association office. The change of ownership is made on the registration certificate.

Herd Registry Books. The dairy breed associations at first published herd registry books which listed every animal that had been registered, with its name and number together with the name and number of its sire and dam. Because of the expense involved in publishing these books all the associations, with the exception of the Holstein Friesian and the Brown Swiss, have discontinued the publication of the herd registry books. The records are kept on file in the association office, and whenever a detailed pedigree is required it can be obtained from the association.

When it is realized that the total number of animals registered to date with the breed associations runs well into the millions in some of the breeds, the magnitude of the job of keeping these records can be seen. However, the life of the purebred dairy breeds depends on the keeping of these records. This, then, is the first and probably the most important duty of the breed association—preserving the purity of the breed.

(b) Improving the Breed. Of course, the association members being breeders of dairy cattle soon became interested in methods

of improving their breed The fact that their cattle were registered and thus were considered purebred was not enough, the breeds had to be improving

Production Testing The mere registration of an animal was not sufficient to insure improvement in the breed Therefore, the early breeders conceived the idea of a system of testing for production, wherein the animals would be put in an advanced registry if they produced the required amount of milk and fat The breed associations started a program to certify the authenticity of the records They called it the official testing program, and it is now conducted under the unified Rules for Official Testing as adopted by the Purebred Dairy Cattle Association and the American Dairy Science Association In each state, someone in the dairy husbandry department of the state agricultural college is named as superintendent of official testing for that state He has the responsibility of seeing that the animals entered on official test are tested at stated intervals To do this, he appoints official testing supervisors who visit the farms, weigh the milk, and test a sample of milk from each cow on test He then prepares a report and sends it to the state superintendent who, in turn, after checking the record, sends it to the breed association, where it is further checked and recorded

There are two divisions of the official testing program, the Advanced Registry and the Herd Improvement Registry, as given in Chapter 27

Publication of Records The records are published in a suitable publication by the various breed associations These publications are available and can be used in many ways, such as determining the value of sires or dams, the writing of pedigrees, and in the selecting of breeding stock.

Improving the Type of the Breed. The breed associations have always been alert to improve the type of their breed

Scale of Points or Score Card Early in the history of the various dairy breed associations, a score card, or scale of points, was developed The purpose was to establish a standard of perfection by which animals could be compared and thus to set a goal toward which breeders could strive In these score cards two objects were kept in mind, one to include those qualities that indi-

cate utility as producers and the other to preserve characteristics peculiar to the breed

At first there was some criticism that the score card put too much emphasis on fancy requirements and that these sometimes outweighed the more practical features of the animal Gow * makes the following statement, "To breed for utility alone, disregarding the different races, would eventually obliterate distinct breeds, and, while the attainment of greater production would be an uncertainty, the procedure certainly would reduce all cattle to a dead level of uniformity and standardization This may be the tendency of the present age, but the aesthetic sense is still strong in humanity, and no association of breeders has as yet thrown its score card in the discard"

Through the influence of the Pure Bred Dairy Cattle Association, the breed associations have adopted a uniform score card This card is uniform for all breeds, with the exception that certain requirements are listed for each breed different from those of the other breeds

True-Type Models and Pictures Most of the breed associations have attempted by painting or by model or both to prepare a representative of the true type of their breed These true type models or pictures, even better than the score card, give the breeders an ideal toward which they should strive to develop the animals in their herds

Dairy Cattle Shows The breed associations have always encouraged the showing of cattle at parish, county, state, and national shows Each of the breed associations selects a dairy show each year and designates it as their national breed show When the National Dairy Exposition was in operation, it was the national show for all breeds Since its discontinuance, different shows have been so designated Some of the associations select one show and others select a list of approved shows The associations have a list of approved judges, one of whom is selected to be the judge for their breed at the approved fairs These shows are a help in establishing and maintaining the true type Here, breeders have an opportunity to compare their animals with others of the same breed

* *The Jersey*, Gow, p 142

Type Classification. Since many breeders do not show their cattle at fairs because of fear of disease or lack of time and labor, the associations started a system of herd classification whereby a classifier comes to the farm and classifies for type or conformation each milking animal in the herd The animals are usually not especially fitted and are in all stages of lactation

Classifiers The classifiers are selected by the association from its list of approved judges They are recognized judges who know breed type and the score card thoroughly and are experienced dairy cattle men

Classification Voluntary The owner may have his herd classified by applying to his breed association for the services of a classifier It is entirely voluntary If he choose to classify, he must present for classification all purebred females that have freshened and have not previously been classified If they have been previously classified, he may present them for reclassification if he chooses to do so Some breed associations reclassify animals that are in the higher groups All the associations except the Guernsey also require the classification of bulls over certain ages and the Ayrshire Association permits the classification of heifers if the breeder so desires

Classification Procedure The animals are rated according to the score card and placed in one of the following categories excellent, very good, good plus, good, fair, and poor The Guernsey Association calls the good plus animals, desirable, and the good animals, acceptable Table LXXIII gives the nomenclature, score, and other data on classification by breeds

TABLE LXXIII

NOMENCLATURE, SCORE, AND OTHER DATA ON CLASSIFICATION BY BREEDS

	Score of Points		
	Ayrshire, Guernsey, & Jersey	Brown Swiss	Holstein
Excellent	90 and above	90 and above	90 and above
Very good	85–90	85–90	85–90
Good plus or desirable	80–85	80–85	80–85
Good or acceptable	75–80	70–80	75–80
Fair	70–75	60–70	65–75
Poor	Under 70	Under 60	Under 65

Most of the associations use a breakdown score card, in which a detailed rating of each of the main divisions of the score card is made on each animal. The following is the type of report used by the Brown Swiss Association.

No	Classification Rating	General Appearance			Dairy Character Rating	Body Capacity Rating	Mammary System			Comments
		Rating	Subratings				Rating	Subrating		
			Legs & Feet	Rump				Fore U.	Rear U	

This breakdown shows the weakness and strong points of the animals classified and is a great aid in eliminating weak points in a herd and in the selection of bulls to improve the type of a herd.

(c) To Advertise and Promote the Breed. The breed associations have the task of advertising and promoting their breed. The testing and the type programs are often ideal for helping in this work. Special awards and programs have been started by the various associations to advertise and promote the breed.

Special Programs and Awards

Constructive or Progressive Breeders' Award. Three of the breed associations give a constructive or progressive breeders' award to those of their members whose herds meet certain requirements. *Table LXXIV gives the requirements of the three* associations, Ayrshire, Jersey, and Holstein-Friesian. The first two of these are called the Constructive Breeders Award, and the Holstein-Friesian calls theirs the Progressive Breeders Award.

TABLE LXXIV

REQUIREMENTS FOR CONSTRUCTIVE AND PROGRESSIVE BREEDERS AWARD

Breed	Cows Home-bred per cent	Cows Home-bred or Owned 4 Years or More per cent	Production per Cow per Year pounds	Classification: Number per cent	Classification: Ave. Score	Disease Free †: T B	Disease Free †: Brucellosis	Breed Association Membership
Ayrshire	50	65	9250 M 3 9% 360 F *	70	82 5			National
Holstein	75		11 600 M 440 F 2x 12 900 M 490 F 3x	66⅔	81	Yes	Yes	National active in local and state
Jersey	75		400 F	60	83	Yes	Yes	Active in local and state

* Converted to 2x M E.
† Either accredited or under federal and state control program.

This is the highest honor given to a breeder by the breed association and is coveted by every progressive breeder

Herd Averages A good herd average is an excellent advertisement for any herd or breed It tells what all the animals are producing and not just what a few of the best animals produced The Ayrshire Holstein Friesian and the Jersey Associations report the herd averages for all herds on Herd Improvement Register The Jersey Association also recognizes the better averages by giving a Gold Star Herd certificate *A Gold Star Herd* is one that has produced 450 pounds of butterfat in a year on Herd Improvement Registry test If the herd has only 10 cows or less the requirement is 475 pounds of butterfat and if the number of cows in the herd is more than 50 cows the requirement is 425 pounds of butterfat

Award to Cows The Ayrshire Breeders Association designates a cow an *Approved Dam* when she has three daughters that average 9250 pounds of milk and 370 pounds of fat with a test of 3 9 per cent or an average of 10 000 pounds of milk and 400 pounds of fat Two daughters will qualify a dam for this award if they average 9500 pounds of milk and 380 pounds of butterfat with a test of 3 9 per cent Approved sire sons can be used in place of one or more daughters

The Jersey Association has several awards for the cows of their breed such as the following

A Silver Medal cow must produce 420 pounds of fat in 305 days when calving at 2 years of age, with an increase of 0 173 pounds for each day over 2 years up to 5 years of age For 365 days, this amount must be increased by 15 per cent Cows must meet calving requirements

A Gold Medal cow must produce 610 pounds of butterfat in 305 days or 700 pounds of butterfat in 365 days, meeting the calving requirements in both cases

A Medal of Merit cow must produce 740 pounds of fat in 305 days or 850 pounds of fat in 365 days, meeting the calving requirements in both cases

A Tested Dam must have 3 or more daughters with production records The average production of the daughters is the cow's rating

A Ton of Gold cow must have produced 2000 pounds of butterfat in 4 consecutive years in Herd Improvement Registry test

The Guernsey Association designates any animal that has (1) completed a production record, or (2) have been placed first, second, or third in any of the major fairs, or (3) that have progeny in either of the above two categories as *Performance Registry animals* and list them in the Performance Registry The *class leaders* are the ten high cows in fat production in each age and testing classification

The Brown Swiss Association places the ten high cows in fat production in each age and testing classification on the *Honor Roll* They also give special recognition to all cows in their breed that produce 4000 pounds of butterfat or more in their lifetime

One hundred thousand pound cows are given an award in most of the associations for cows who during their lifetime produce 100,000 pounds of milk or more

Awards to Sires The Ayrshire Association has an *approved sire program* When a sire has at least seven unselected daughters out of tested dams that average 9250 pounds of milk and 370 pounds of fat with a test of 3 9 per cent or more, or an average of 10,000 pounds of milk and 400 pounds of fat, he is listed as an *Approved Sire for Production* In their records his regression index must not be less than 9100 pounds of milk and 370 pounds of fat All records are calculated to 2 times 305 day

mature equivalent bases At least 50 per cent of his daughters that have reached the age of 3 years must have been tested

A sire in this breed may be *Approved for Type* when ten or more of his daughters average 82.5 per cent on type A minimum of 50 per cent of his daughters that are 3 years or more of age must have been classified When a sire qualifies for approval in both type and production, he is designated as a *Double Approved Sire*

The Holstein Friesian Association has several awards for sires A sire becomes a *Silver Medal Production Sire* on a daughter dam comparison of at least 10 pairs that meet the following requirements (1) the daughters average at least 410 pounds of fat (2 × 305 d M E) with not less than 3 4 per cent fat, (2) the production must exceed "expectancy" by at least 40 pounds (Expectancy is the point halfway between the breed average and the average production of their dams)

A Silver Medal Type Sire is one which has a minimum of ten daughters classified (at least 75 per cent of his available daughters) and meet one of the following requirements (1) type score of 84 per cent when less than one fourth of his daughters are classified, (2) type score of 83 per cent when one fourth to one half of his daughters are classified (3) type score of 82 per cent when one half to three fourths of his daughters are classified, and (4) Type Score of 81 when more than three fourths of his daughters are classified The number of registered daughters include all registered daughters dead or alive, that were born 3 years previously and all other daughters that have freshened

A Gold Medal Proved Sire is one that has met both the type and production requirements for a silver medal

Beginning in 1953 the Holstein Association also approved a *Program of Selective Registration* of bulls To be so rated, a bull s pedigree must show evidence of satisfactory production and desirable type

The Jersey Association has many awards and recognitions for sires

The Star Bull Program is a plan to rate a bull on the basis of his probable inheritance of production and type as evidenced by his pedigree A bull may have anywhere from one to seven stars on that basis

The Selective Registration of bulls is a program that became effective in 1942 to encourage the registration of only the better bull calves. A special purple-edge certificate is used for this designation. To qualify, a bull must meet one of the following requirements: (1) his sire must be a proved sire whose daughters average not less than 400 pounds of butterfat; (2) his dam must have a record of not less than 400 pounds of butterfat (2×305 d.M.E. basis); or (3) his sire must be a Star Bull.

Silver-Medal Sires, Gold Medal Sires, and *Medal of Merit Sires* are sires that have at least three daughters that have qualified for these awards.

A Tested Sire is a sire with ten or more tested daughters (records averaged on 2×305 d.M.E. basis).

A Superior Sire is a tested sire whose daughters average 8400 pounds of milk and 470 pounds of fat or more and the type score of at least ten of his daughters is 83 per cent or more. Fifty per cent of his daughters must be classified and tested.

A Senior Superior Sire is a Superior Sire with twenty daughters that average 9500 pounds of milk and 510 pounds of fat or more and with type ratings on his daughters of 84 per cent or more.

Milk Programs. To help with the promotion of the breeds, the Guernsey and the Jersey Associations have developed a breed milk-selling program. The Guernsey Association's program goes under the name of Golden Guernsey milk, whereas the Jersey Association's program is called all Jersey milk or Jersey Creamline milk. The association licenses the producers and distributors and requires that they adopt certain sanitary practices and have certain equipment necessary for the production of quality milk.

Extension Work. Extension work has been carried on by the various associations for advertising and promoting the breeds. It is done in several ways: namely, by preparing and mailing out printed information on the breed; by assisting at shows featuring the breed; by demonstrations and special exhibits at fairs and expositions; by publishing production records; by press advertising; by moving pictures of the breed; and by other forms of field work.

Fieldmen. The breed fieldman is the association's means of contact with the breeders. He is a promoter. He attends meet-

ings of the breed clubs and other dairy meetings in the interest of the breed he represents, he helps organize state and local breeders' clubs, he work with exhibitors at fairs and shows, always trying to bring his breed to the attention of more people, he works with 4-H and FFA club members, and gives service to the breeders whenever possible in matters of registration, transfers, testing, classification, showing, sales, and other problems dealing with his association The breed fieldman is an important link between the breeder and the association

Breed Papers The breed papers published monthly or semimonthly for the various breeds is one of the best mediums for advertising and promoting the breed The *Ayrshire Digest*, the *Brown Swiss Bulletin*, the *Jersey Journal*, and the *Guernsey Breeders' Journal* are published by the respective breed associations The other two, namely, the *Jersey Bulletin* and the *Holstein Friesian World* are published by independent organizations

Breed Histories Histories of the breeds have been written in part in many books on breeds of livestock and in other publications Several books, such as *The Jersey*, by R M Gow, *The Guernsey Breed*, by W H Caldwell and *The Holstein Friesian History*, by Prescott, Price and others, have had their influence in advertising and promoting the breeds

The Purebred Dairy Cattle Association

The five dairy breed registry associations in 1940 formed the Purebred Dairy Cattle Association. The purpose of this association was to make a unified effort to promote purebred dairy cattle and to work out uniform programs that concerned all of the breeds Their cooperative action has produced the following results

1 A unified dairy-cattle score card

2. Unified rules for official testing

3 Unified rules and regulations governing registration of artificially bred dairy animals

4. A list of classes and order of judging in one and two day dairy shows.

5 A code of ethics for public and private sales.

These uniform rules and regulations have greatly helped in promoting the breed programs and have done much to advance the purebred business.

REFERENCES FOR FURTHER STUDY

1. Herd books and production books of each breed association.
2. Caldwell, *The Guernsey*, the American Guernsey Cattle Club, 1941.
3. Prescott and others, The Holstein-Friesian History, *Holstein-Friesian World* (1930).
4. Gow, *The Jersey*, the American Jersey Cattle Club, 1936.
5. Annual reports of the breed associations
6. Breed papers.
7. *Unified Rules for Official Testing*, the Purebred Dairy Cattle Assoc.

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The Purebred Dairy Cattle Business

The breeder of purebred dairy cattle is engaged in two separate and distinct enterprises: first, the production and selling of milk, and second, the developing and selling of seed stock. To many, the challenge of developing a herd of superior animals is the spark that gives them keen interest in the business. The breeding of a herd of purebred animals can be profitable and fascinating for those who will take the time and trouble to carry out the exacting details that are necessary. However, not every one should be a purebred breeder.

Purebred Dairy Animals. In this country, a purebred dairy animal is one that has come, or whose ancestors have come, from the native home of the breed and that conforms to the requirements of the breed. Purebred dairy cattle of today are the result of long years of breeding and selecting for characters that the breeders desired to develop. There are five major dairy breeds in this country and several minor ones, but many other dairy breeds are found in other parts of the world. For example, on the continent of Europe there are between forty and fifty breeds of cattle. Great Britain is the native home of eleven breeds that have been imported to America, besides several others of importance in their native home.

Although all cattle have some inheritance in common, the dairy breeds have additional similarity in their inheritance. They have all been selected not only for their breed characteristics but also for their ability to produce large quantities of milk and butterfat economically. Just when the cattle in their native homes became established as breeds is not fully known, but with few exceptions the breeds of today have been established for a long period of time. For example, it was reported in 1855

that the cattle on the island of Jersey had been kept pure for 500 years. In 1833, the Royal Jersey Agricultural and Horticultural Society adopted rules and regulations for the improvement of the breed, but it was not until 1866 that a Herd Book was established for the registration of the cattle Although all the cattle were purebreds, only those that passed inspection by a committee were eligible for registration Most other breeds started registration at about the same time and in much the same way as did the Jerseys, but of course, the requirements differ in details

Registered Animals. A registered animal is a purebred animal whose name has been registered with its respective breed association and for which a certificate of registration has been issued by the association A purebred animal is not always registered. This usually is the result of neglect of the owner to fill out an application for registry If the sire and dam are registered, these animals can usually be registered at any time, if breeding and birth records are available, but at an increased fee if delayed beyond a specified age If, however, the ancestry has not been registered or if breeding and birth records are not available, the animal can never be registered and is classed as a grade It is important that a complete record be kept of service and birth dates

A buyer should always insist on securing the registration certificate at time of purchase, and see to it that proper transfer is made. The new breeder is often fooled when purchasing an animal which is entitled to registry but which for some reason is not registered This new breeder, often a beginner, may not know that it is necessary for him to secure the registration papers and to have the ownership of the animal transferred to his name on the books of the breed association This responsibility lies with the seller but sometimes he neglects his duty, causing disappointments and lack of interest by the new breeder

Purpose of the Purebred. The purebreds are the seed stock of our dairy cattle industry Only about 5 per cent of the dairy cattle in this country are purebred animals but the grade animals owe most of their good qualities to their purebred blood, usually obtained through purebred sires The best inheritance of desirable qualities has been developed and preserved in the

purebreds. Their continued development will depend on further concentrating desirable qualities and diluting unwanted characters. The continued purpose, therefore, of purebred herds is to perpetuate the desirable characters in the purebreds and to furnish these characters for the improvements of the grade herds.

Comparison of Purebreds and Grades. Grade herds have been developed that will produce as much and sometimes even more than many purebred herds. Such herds are usually high grades having from 95 to 99 per cent of their inheritance from high quality purebreds. The production of purebreds in DHIA averages from 25 to 30 more pounds of butterfat per cow annually than produced by grades.

Table LXXV gives the average production of cows in various

TABLE LXXV

AVERAGE PRODUCTION PER YEAR OF COWS IN DIFFERENT CLASSIFICATIONS

	Milk, pounds	Fat, pounds
All cows milked in U. S. (1950) *	5,292	210
All cows in D. H. I. A. (1950) *	9,172	370
Ayrshire (H. I. R. 1950) †	9,544	389
Brown Swiss (H. I. R. 1950) ‡	9,915	402
Guernsey (H. I. R. 1950) †	8,142	396
Holstein (H. I. R. 1950) †	11,616	418
Jersey (H. I. R. 1950) †	7,249	387

* *Rept. Chief Bur. Dairy Ind.* (1951)
† *Rept. Breed Assoc.*
‡ Calculated from Breed Assoc. Rept.

classifications. It must be kept in mind, when studying these facts, that they may not, in all cases, represent comparable conditions.

Requirements of a Purebred Herd. If the purebred herds in this country are to furnish the seed for improvement of the grade herds, it is necessary that they meet certain requirements. These requirements are as follows:

1. HIGH PRODUCTION. The first requisite of a purebred is that it be a profitable producer. All cows in a purebred herd should

be fed and managed in such a way that a true measure of their average producing ability can be obtained

2 Good Type Although type and production have some relationship, a breeder cannot get high production by selecting only for type, or superior type by selecting only for production The two characters, type and production, are both necessary in a good purebred herd Cows with poor type, even though they have good production, are discriminated against in the buyer s market Cows with poorer production but with good type will often outsell them The classification of dairy cows is the best measure for type now available

3 Health A purebred herd should be healthy It should be accredited free from tuberculosis and be either accredited free from or clean and calfhood vaccinated for Brucellosis It should be kept free of any infectious diseases such as mastitis, Johne s disease, vibrio fetus, and trichomoniasis Otherwise, trouble will be experienced in selling breeding animals Furthermore, most of these diseases affect milk production Therefore, it is difficult to get a true measure of the breeding worth of a diseased individual

4 Comfortable and Sanitary Surroundings Although it is not necessary that a purebred herd be maintained in elaborate and expensive barns and surroundings, these should be neat, clean, and comfortable to the animals

THE PUREBRED BREEDER

Classes of Breeders There are two rather distinct classes of breeders with others ranging between The first is the established breeder with a well developed and highly productive herd This group includes the great breeders who have done much toward breed improvement From this class the bulls and foundation cows for the second group are supplied The stock from the first group usually is too high in price for the breeders of grade cattle The second class of purebred breeders consists of those not so well established in the business and whose herds have not been so highly improved The beginner will usually find himself in this class His ability as a breeder will determine whether or not he will continue in this class From this

class of herds many of the bulls which are used in grade herds are produced.

The Characteristics of a Purebred Breeder The characteristics that a purebred breeder of dairy cattle should have are many and varied Breeders who are to raise the seed stock for the mass of dairymen have great responsibility and should have certain qualities Some of these characteristics are necessary, others are desirable, yet their absence may be overcome These characteristics are as follows

1 Love for the Dairy Cow Unless a man has a sincere love for a dairy cow, he will never be a great breeder If a person loves a dairy cow he will see that it is fed and managed in such a way that it will be given a chance to produce to its maximum Cows will respond to kindness and a good breeder will so influence those who work with his herd that the cattle will receive only the best of treatment.

2 Knowledge of the Following

(*a*) *Feeding* A good breeder should not only love his animals but be well informed on feeding Unless cows are fed intelligently their production will not reflect their true inheritance and the success or failure of a breeding program depends largely upon an accurate measure of the cows productive capacity

(*b*) *Breeding* Any program for the improvement of a herd must be based on the science of genetics Unless a breeder is acquainted with at least some of the fundamentals of breeding it will be difficult for him to build a good herd

(*c*) *Type* A good breeder should have a definite idea of the good traits that a dairy animal should have He need not be an expert judge but he should know when an animal has good type or when she does not

(*d*) *Pedigrees* A successful breeder usually is a student of pedigrees He should know the family lines that are important in his breed and above all, he should know the families in his own herd.

3 Pay Attention to Details Many details are involved in a breeding program and unless the dairyman pays attention to these he will never become a successful breeder

4. Ability to Withstand Disappointments In the breeding of animals, there are often many disappointments Choice animals may be lost to the herd through injury, sterility, or death The bull that had been counted on for the development of the herd may not turn out as expected. These and many other disappointments that may occur should not discourage the breeder but should only strengthen his resolve to develop an even greater animal or herd

5. Integrity The purebred business is based on the honesty of the breeder and accuracy of his records Men who have a reputation for honest dealing and whose word is as good as their bond are the ones that are making a success in breeding dairy cattle The breeder who honestly helps those who buy from him or who will not sell an animal to a breeder if he knows that it is not to the best interest of the buyer is more likely to make a success as a breeder

Time Needed to Develop into a Breeder. A dairyman who has bred and developed good animals through several generations is considered a good breeder At least three generations of from 3 to 5 years each usually are required before a breeder can be considered to have contributed much in his own right. Of course, a person may be fortunate in purchasing a sire at the start that becomes an outstanding breeding bull and, thus, produce a group of high-producing cows in one generation However, this immediate success is no assurance that the desirable characters will be fixed in the herd and that the cows will continue to breed true for high production The breeder in this case was "lucky" in his sire selection, but this does not prove him to be a great breeder Careful selection within a herd throughout the period of development will tend to make the animals more uniform in their genetic make-up The farmer-breeder often remains in the breeding business longer than the big breeder Big herds often are not started until after the person has been successful in some other business and wishes to invest his money in a herd of dairy cattle The remainder of his life expectancy and consequently that of the herd is often limited

Copeland,* in a study of 2000 Jersey breeders, found that at

* *Jersey Bull* (Nov 22, 1933).

the end of 5 years only two-thirds were registering cattle, after 10 years only 40 per cent were registering cattle, and after 15 years only 25 per cent were still in the business. Farmer-breeders often may continue for several generations, the herd passing from father to son

Management Details. There are many details in the management of a purebred dairy herd that a breeder must pay attention to if he is to be a success.

1 CARE IN REGISTRATIONS AND TRANSFERS One of the marks of a good breeder is that he is careful in the registration of his animals and is prompt in transferring them when they are sold The chore of drawing color markings, taking pictures of the animal, or tattooing the animal in the ear in order to have it properly registered must be promptly done To some this is an unpleasant task and is often neglected Many purebred animals have been lost to the breed because they were not registered when they should have been, and later their identity had been lost.

2 PROMPT IN ANSWERING INQUIRIES. The breeder is in business He will receive many inquiries by mail concerning animals in the herd The successful breeder will answer these inquiries promptly and efficiently He will use an attractive letterhead and whenever possible have the letters typewritten, keeping a carbon copy of all such correspondence for future reference.

3 PROVIDE FOR A FARM NAME. The use of a farm name can be an asset to the purebred breeder The name should be distinctive and meaningful It may be and often is, used as a prefix in naming the animals bred by the breeder and thus will identify them anywhere the name appears This name may be registered with the breed association for the exclusive use of that breeder as a prefix for naming his animals

4 DEVELOP A SYSTEM FOR NAMING ANIMALS In naming animals the use of a farm name prefix is convenient for beginning the name There are a number of systematic plans for naming animals, for example, in the name Midview Majesty's Belle, the name "Midview" is the farm name used as a prefix on the name of all animals registered by that breeder, "Majesty" is a part of the sire's name and is used as the second part of the name

of all his offspring, and 'Belle" is the individual animal's name and indicates that she is a member of the "B" cow family in that herd All animals belonging to this same cow family have their last name beginning with the letter 'B"

Another naming system uses an additional name and gives more information, for example, in the name VPI Majesty Emily June, the 'VPI" is the prefix, 'Majesty" indicates the sire, 'Emily" is the last name of the dam, and "June' is the individual name of the animal At this farm, all the animals born in the same calendar year have a last name beginning with the same letter, whereas the next year the next letter of the alphabet is used, and so on This system has the added advantage of indicating the animal's age and the last name is distinctive for that cow There are many desirable systems of naming cows in the herd The breeder should adopt one and use it for all his animals

5 Help with Local, State, and National Programs The national breed associations have a number of important programs established in which breeders may participate if they wish These have been discussed in another chapter The two basic programs are (1) the production testing program and (2) the type classification program The other programs are largely based on these two and a successful breeder will have his herd entered in both He will also be interested in the local and state breed clubs of his particular breed He will be interested in the health programs and will keep his herd free from disease

Good Business Methods Necessary. A breeder must be a successful farmer and dairyman He must be progressive in his methods as indicated by the following criteria

1 Providing abundant pasture for his herd
2 Producing the right kind and amount of crops
3 Maintaining high milk production
4 Producing quality milk
5 Keeping milk production costs at a profitable level
6 Maintaining desirable and efficient help
7 Using up-to-date equipment to the extent his finances will permit
8 Maintaining neat and orderly premises
9 Maintaining adequate though not necessarily elaborate buildings

10 *Staying on a financially sound basis*, avoiding splurging in a way to jeopardize the business

11 Registering and transferring promptly and answering letters promptly and efficiently

12 Taking part in the program of the national, state, and local clubs

Working with Another Breeder. Usually, a young or new breeder should work closely with a well established breeder They can often be of mutual help By continually using sires bred by the established breeder the young breeder will eventually have a herd bred quite similarly to the established breeder and will profit by the advertisement of the better known establishment It will also benefit the older breeder because he will have a place to try out some of his most promising young bulls that he may want to use later in his own herd

If two breeders are in the same locality, they can be of great help to one another They may go together to meetings, shows, and sales They may cooperate in the buying of foundation animals, especially bulls They may exchange bulls and counsel. A group of breeders interested in one breed can do much to improve the breed and their herds by working together

What the Purebred Breeder May Expect The breeder of purebred cattle who must invest more in his business than the commercial dairyman should have the right to expect a greater return for this additional investment and effort If the herd and the farm are operated on a sound basis and attention is given to all the details, he should be rewarded by the following results

1 Having high milk production
2 Getting a high price for cattle
3 Breeding outstanding cattle
4 The opportunity for leadership
5 The pride in ownership of outstanding animals
6 The possibility of building up a herd of high value, which will be used for an estate an annuity, etc

Selling Seed Stock. In selling the surplus females and the bull calves, a reputation for honesty and fair dealing is a great asset If, over the years, a breeder has a good reputation and has high quality animals to sell, his selling problem will be at a minimum

In order to sell animals efficiently it is necessary to do the following. (*a*) *Advertise.* This can be done in local papers or in the national breed magazines. Advertising is a necessity. (*b*) *Exhibit.* One of the best ways to advertise is to exhibit some of the better animals in local, state, or national shows.

If the herd is advertised, there are several ways to effect sales: (1) by private treaty; (2) by consigning to sales of various kinds; or (3) by mail. The advantages and disadvantages of each of these methods will be discussed later.

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Marketing Dairy Cattle

The dairy enterprise on a farm may represent only a portion of the total farm income or it may be the sole source of income The major part of the dairy income may come from the sale of milk, but often on a farm where purebreds are kept a portion may come from the sale of dairy cattle

A dairyman may find that with improvement of the fertility of his land and the accompanying increase in yields of pasture and other crops he can increase the number of livestock on his farm Of course, there may be limiting factors to such an increase in cow numbers such as lack of barn space, additional labor needed in caring for and milking the extra cows, and the marketing of the additional milk.

Many dairymen, to meet this situation, raise additional dairy animals to sell All the good heifer calves dropped in the herd are raised and even some calves and heifers may be purchased and raised for later sale

Those heifers not needed for herd replacements may be sold whenever there is a demand for them It is the usual practice however, to sell the majority of them as heavy springers or soon after calving If the dairyman wishes to maintain a young herd he may sell the older cows or those still in their prime (5 to 6 years of age) and retain the first-calf heifers This practice will usually result in a somewhat lower herd production but, on the other hand it will lower the number of cows to be disposed of to the butcher because of old age, udder trouble, nonbreeding, and other troubles

WHEN TO SELL COWS

Time of Freshening. Usually, the greatest demand for dairy cattle is for fresh cows or heavy springers The advantage of buying springers (cows or heifers before freshening) are (1) they will stand transportation better than the fresh cow, with less danger of udder injury, (2) they reach their new home in time to become accustomed to the new surroundings before they calve and are to be milked, and (3) the buyer has a chance of getting a valuable calf Of course, half of the calves will be bulls

The fresh cow or heifer has her production interrupted somewhat in making the change, but the advantages of buying at that time are (1) many buyers need the milk at once and are not willing to wait for the cow to freshen, (2) the buyer can be sure that there are no blind or weak quarters, and the shape and attachments of the udder can be determined better, (3) the amount of immediate production is a matter of record, and (4) there is not the problem of difficult calving, retained placenta, or milk fever

Although there are advantages both ways, the fresh cow or heifer usually will bring a little higher price than will the springer, especially in auction sales

Season of the Year The season of the year seems to have quite an effect on the demand for dairy cattle Calves and yearlings are in heavier demand in the spring, when they can be turned out to pasture

Milking cows and close springers are in greatest demand in the fall as this is the time of greatest demand for milk and is the period when the base for the year is determined for many dairymen selling fluid milk

Some differences between breeds exist as to the best season of the year to sell On most markets there is a surplus of milk in the spring and early summer which favors the higher testing breeds Since in the fall the demand is for volume of milk, the high testing cows do not hold their advantage

MARKETING GRADE CATTLE

The marketing of grade cattle is somewhat different than the marketing of purebreds The market for grades is largely to commercial dairymen near large cities who do not raise their own replacements in sufficient numbers There is, of course, also a continual change of dairymen, some going into the business and others going out, those going into the business must purchase cattle, and they usually start with grades

Good grade cows that have been bred up from good purebred sires of the same breed for a few generations will be quite uniform They will have the color markings, conformation, and general characteristics of the breed Where culling and selection has been practiced, high production can be expected

Some dairymen with surplus cattle maintain a standing agreement with other commercial dairymen to supply them with fresh cows and springers Others sell regularly to dairy cattle commission men and still others have no regular method of disposal of their surplus A few grade dairy animals are still sold through livestock auction markets This is certainly an undesirable place to secure dairy cattle These markets have been developed to furnish a market for surplus livestock of most any kind In most cases the animals that are sold are expected to go to slaughter They come from all kinds of farms and too often little effort is made to control disease This offers a market for cull cows that should go to the butcher A dairyman should not buy animals of any kind from these stockyard markets The author does not know of a profitable herd where the owner has made a practice of purchasing replacements from the stockyard market, but does know of several dairymen who purchased a great deal of trouble with cattle from this source Probably the most prevalent of these troubles have been cows with mastitis, Brucellosis chronic digestive troubles or mean dispositions

MARKETING PUREBREDS

Registered cows must make good at the pail however, their value extends beyond their milk producing value The demand for them is based on their value as foundation animals on which

to build or improve a registered herd. Top-flight herds look to other registered herds for their sales.

The small purebred breeders will expect most of their sales to go as foundation for new breeders or for those breeders with only a few purebreds

Bull Calves. The market for bull calves is much more limited than for females The greatest demand is for young bulls of breeding age, usually in the fall and early winter

The widespread growth of artificial breeding associations has reduced the number of bulls needed and at the same time has made the demand much more discriminating.

New Breeders A new breeder of registered dairy cattle must not at first expect high prices or too great a demand for his surplus cattle He must first build his herd on a sound financial operation from the sale of milk After he has established a healthy herd that has satisfactory production records and desirable type, as indicated by classification or by showing at local shows, and after he has advertised by some method, he can expect some demand for his animals

Certain factors are essential for a breeder wishing to sell surplus cattle His herd must have the following qualities

(1) Production Records High producing ability is the first requisite of registered dairy cattle The proof of producing ability is through one of the systems of production testing For selling locally or even within the state, records made in D H I A usually are accepted about equally with official test records For national, sectional, or special sales the official test record usually commands higher prices for cattle

(2) Type Type is the second requisite for the purebred breeder Copeland * and Norton † made studies of the production records of cows that had been classified for type When considered as groups there was a correlation between the classification rating and production The better type cows, on the average, produced more than the poorer type cows Although this was true for group averages it did not hold true for all individual cows

* *Jersey Herd Classification Bull*
† *Holstein Herd Classification Bull*

To secure some of the higher prices, purebred cattle must have desirable type, but it is not necessary that they be showring winners A part of the desire for ownership of registered cattle is in the pride of having something better

One of the top flight sale managers stated that when he selected cattle he looked first at the animal, then at the pedigree, and that a splendid pedigree and a high record would not sell an off type animal

(3) HEALTH The third requisite for a breeder wishing to sell his surplus stock is to have a healthy herd—a herd that is free of Brucellosis, tuberculosis, mastitis, and other diseases He should develop an accredited herd Some buyers prefer to purchase animals that have been calfhood vaccinated for Brucellosis All animals to be sold should have a negative test for both Brucellosis and tuberculosis within 30 days of the selling or delivery date In most states, calfhood vaccinates that have not cleared up, but are under 24 months of age and come from a clean herd are acceptable animals from a health standpoint An attempt should be made to sell cows free from mastitis and other diseases It is the seller s obligation to sell only healthy animals

ADVERTISING

Besides developing a herd with high production, with good type and free from disease, the breeder must advertise if he wishes to sell his surplus cattle to advantage

The art of advertising is to let the prospective buyer know what one has to sell and to present its good points in such a way that the buyer will want what one has to offer

Some advertising may be free and other kinds may cost money, but whatever the cost it may be placed in the same category as the expense of raising the animal to sell It is a necessary part of the sales program

There are many ways to advertise, among which may be listed the following

1 Showing animals at local or state fairs If this is to be done, the right kind of animals must be shown and they must be well fitted and shown in an attractive manner Signs over the heads

of the herd and printed material of information about the herd can be distributed.

2 Furnish the local papers with information on the outstanding accomplishments of the herd The production records, its classification, or show-ring winnings are always news that the local paper will take without cost

3 Consigning a few top animals to a local or state consignment sale is another means of getting a herd before the buying public The sale as well as the show can be a breeder's show window through which to display his merchandise

4 Purchased advertising space in local papers or breed magazines may at times be one of the most wisely spent costs of selling cattle It may reach the person in need of the specific offering The type and extent of purchased advertising that is justified depends upon the number and kind of animals to be sold

A beginner would not expect to advertise his surplus through a national medium He could expect his best results with local papers or probably state wide types of farm papers The use of continuous small advertisements are more effective than a single large one costing the same amount

5 A breeder's reputation for honesty and integrity is the greatest advertisement for a herd of cattle A reputation for square dealing is a requisite for a man to sell cattle at the best prices This is true for either private or public sales

The activity of the breeder in breed clubs, dairy, and other types of organizations, is effective in getting to know more people and to have more people to know about his cattle A man and his cattle are closely tied together in the thinking of his fellow breeders

METHOD OF SELLING

Surplus animals may be sold in several ways, such as privately, by mail, or through one of the various forms of auction sales

Private Sales. The simplest and most used method of selling is by private sale direct from the seller to the buyer right on the seller's farm

The buyer sees the cattle in their usual surroundings in their "everyday clothes" The seller does not have any selling ex-

pense Blemishes, if any, can be looked over with deliberation. Related animals in the herd can be seen More time can be given to making decisions This method offers advantages that the auction sale does not

Many buyers do not like to buy under the excitement and pressure of the auction sale At the farm they can see the cows milked They can learn more about the feeding and care of the herd as compared to their own

The seller should have readily available and complete production records, breeding dates, and other information on his cattle Some pedigree information should be available Most buyers of purebred cattle today expect much more pedigree information than is on the registration paper

Selling by Mail When travel was more difficult and slower than it is today, there was considerable selling of cattle by mail. This was especially true of bull calves Many sales are still made in that manner, especially by the larger breeders

In selling by mail, the seller should give the interested party as complete information as possible This should include the age, a complete four generation pedigree, a photograph of the animal, and, if possible, of the sire and dam

This type of information is splendid for answering inquiries for cattle, even though the prospect is expected to come to the farm to see the cattle In fact, it may be the deciding factor as to whether or not he will visit the farm

The Auction Sale The auction sale is a quite popular method of selling. A number of animals can be sold in a briefer time A buyer can purchase more animals in a shorter time and with less traveling than he can privately

DISPERSAL SALES The dispersal sale is one where the breeder is selling his entire herd, with perhaps a few exceptions that are noted in the announcement of the sale This is a popular type of sale Breeders realize that they have an opportunity to purchase animals that might not otherwise be offered.

REDUCTION SALE. The reduction sale is one held to reduce the number of animals in the herd The owner has the privilege of selecting the animals to sell. This may be an average cross section of the herd or it may be above or below the average

Consignment Sale The consignment sale is usually conducted by some breed club or group of breeders The breed club consignment sale is made up of cattle selected from the herds of the members A sale may also be sponsored by a group of breeders having the same blood lines or other characteristics common to their herds

Some consignment sales are managed by professional sale managers Others are handled by a sale committee selected from among the group sponsoring the sale When sales are held as annual affairs, they can build up good will and prestige that is a definite asset in selling cattle

THE EVALUATION OF CATTLE

It is often said that an animal is worth what it will bring Of course in an auction sale this is the value placed on it But on the farm how is the price to be determined? Both the buyer and the seller may compare the animal with other animals that have recently been sold But what is a cow worth? A number of factors and conditions enter into the worth of a dairy animal Those listed below are important

Age Generally, an animal increases in value until it reaches its prime, after which its value will decrease In the case of outstanding breeding animals, their value remains high to an older age because of the value of their offspring

Soundness A blemish or unsoundness decreases the worth of an animal The blemish may be negligible or it may be so great that the animal has value only for beef A slightly capped hip that does not interfere with the animal s walking might not cause a serious reduction On the other hand, an injured stifle that causes the animal to walk with difficulty might render her almost totally useless

Health There are probably four diseases that are looked into first namely, Brucellosis other reproductive diseases mastitis, and tuberculosis The health of the individual and also of the entire herd must be considered Numerous other diseases are important

Condition The flesh and the condition of the hair of an animal will materially affect the price of an animal For animals

sold at home the condition will not affect its selling price as much as in a public sale

Cows and heifers that are extremely thin at calving time will not produce their best during the following lactation Yearlings that are ready to go on pasture in the spring might not be discounted much for lack of flesh if they are thrifty and have good skeletal growth Overfatness, especially in young cattle, is not looked on with favor

Present Production If a cow is being purchased primarily to help out the immediate milk supply, her present production is of utmost importance Also this may be a moderately good guarantee of her ability to produce

Past Production When the present production is known the added information of past production gives more assurance as to what to expect during the remainder of the present lactation and subsequent lactations Previous records are always valuable

Bred or Open A buyer must know when a heifer or a cow has been bred The bred animal is just that much nearer to the time when she will start to bring in an income

When Due to Calve A man buying cattle for production at a specific time will pay well for those calving at the time that he will need the milk but will not be so interested in those due much earlier or later

Service Sire In top quality purebred animals the service sire often influences her value He may be a bull whose calves are sought after or he may be a mediocre or poor bull which may detract from the value of the animal

Ancestry A great deal of importance is placed on the ancestry of high quality cattle The value of average cattle is not influenced so much by the ancestors but many breeders will not consider buying animals except within certain families or blood lines

Type and Conformation A poor type animal regardless of pedigree usually will not command a high price Occasionally if the buyer is interested in showing the animal that is a show prospect takes on added value In the majority of cases the consideration is whether or not the animal is typical of the breed is straight with plenty of strength, has a great deal of middle and has a satisfactory udder

Disposition. All other factors could be favorable and the cow have a nervous or bad disposition. She might be a kicker, be difficult to handle, or be a slow or hard milker. The author knows a breeder who sold practically all the daughters of a certain sire because they were hard to handle and difficult to milk. Other considerations help determine what a cow is worth, but these are the more basic.

When all these factors have been taken into consideration and it is found that the animal is sound, a basis for pricing a registered animal on the farm would be to start with one animal and base the value of the others on it according to the following schedule:

	Per Cent
Cows, 3 to 6 years old	100
Cows, 2 to 3 years old	75
Heifers, bred	60
Heifers, 12 to 18 months old	50
Heifers, 6 to 12 months old	40
Heifers, under 6 months	25–40
Heifers, at birth	20–25

Deduct 20 to 25 per cent yearly for cows over 6 years of age. Add 25 per cent for each 100 pounds of butterfat above 400 pounds based on 2×305 day mature equivalent records.

Grades. For grade cattle, the milking cows are worth more in proportion to the value of the calves and yearlings than with purebreds.

Bulls. The same generalizations cannot be made on the worth of bulls as for females. The demand is different and is more exacting. Normally, young bulls from 1 to 2 years of age are in greatest demand. Three- to 5 year old bulls are as a rule difficult to sell. They will not command any higher price than a yearling. At this age they are yet unproved, except in unusual cases. Dairymen hesitate to buy a mature, unproved bull. Most bulls are 6 years old or older before they are proved. The value at this age depends largely on two factors, how good is his proof and how sure a breeder is he? The use of proved bulls in artificial breeding associations is increasing the price on well proved bulls, even of advanced years.

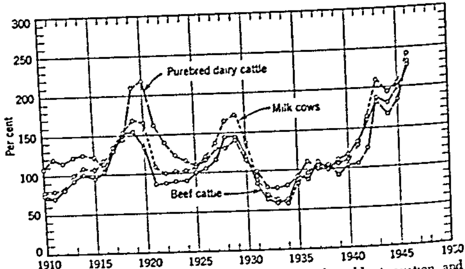

Fig 41 Prices received for purebred dairy cattle sold at auction and United States farm prices of commercial milk cows and beef cattle, 1910–46 Index numbers (1935–39 = 100) (*Dowell and Brekke, Minn Sta Bul 398*)

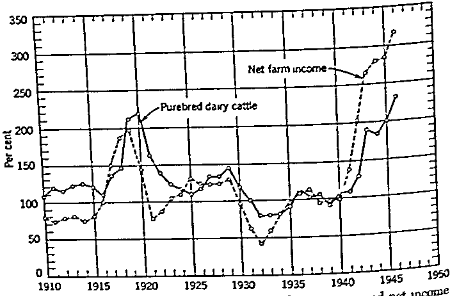

Fig 42 Prices received for purebred dairy cattle at auction and net income of farm operators in the United States, 1910–46 Index numbers (1935–39 = 100) (*Dowell and Brekke, Minn Sta Bul. 398*)

The marketing of dairy cattle is a part of our national economy which relocates surplus cattle from one farm or area into a deficit area The prevailing price will be reflected in the balance of the supply and demand The trend of prices of purebred cattle from 1910 to 1946 is reported by Minnesota workers * The price of purebred dairy cattle sold at auction has followed closely the trend of net farm income (see Figure 42)

This same study compared the prices received for purebred dairy cattle with prices received for milk cows and for beef for slaughter This trend is shown in Figure 41 The value of *milk cows remained closer to the price of beef cattle than it did* to the price of purebred dairy cattle

The price of purebred dairy cattle did not fluctuate so greatly as the price of purebred beef cattle, but it moved in the same general trend

SELLING FROM THE BOTTOM OF THE HERD

Every herd has some cows that are not so good as others Some cows, because of breeding difficulties, udder trouble, injuries, etc , can be sold only to the butcher Some cows are low producers and should be sold to the butcher Some of the low producers in a high producing herd may be better than the average cow in many of the lower producing herds These low producers often bring just about commercial milk cow prices, but the breeder can sell from the bottom of his herd

These lower quality animals should be sold for what they are and not to another breeder for foundation animals on which to build a herd Old and blemished cows of good breeding and with high production may sometimes give a new breeder an opportunity to secure good blood lines at low cost

VALUE TO THE BREEDER

The selling of registered cattle and the contact with other breeders is a part of the romance of the dairy business Dairying and the breeding of good cattle may be a vitally interesting

* *Minn Exp Sta Bul* 398

and profitable business. There are values not measured entirely in monetary units.

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Fitting Dairy Animals for Show and Sale

The breeder of dairy cattle should consider not only the production of his cows but also their type Production and type go hand in hand in the best breeding establishments One of the most effective means of establishing type and of advertising a herd is by the public exhibition of dairy animals The standard of type of the different breeds is largely set at the great exhibitions, although the classification of herds by the different breed associations is becoming more general

The great dairy shows in this country, the different state fairs, and to a lesser extent the county fairs, are excellent educational institutions If one wishes to become acquainted with the desired type of any particular breed, one can do so by watching the placements as made at some of the good dairy shows

The fairs in the United States are not conducted as they are abroad It was the privilege of one of the authors to visit some of the agricultural fairs in Europe At Cooper, when the West Highland Cattle Show had been in progress only 1 day, it was possible to buy a catalog in which could be found the placement of all the cattle in the different classes The animals were placed the day before the opening of the fair so that even those persons who attended only the first day might know how the different classes were placed In this country, it often happens that some of the breeds are not placed until the last day of the exhibition, and unless one remains until then it is impossible to learn all the lessons taught by actual placement in the ring Here, however, we have the pleasure of watching the judge working and of forming our own opinions of the placements before he has actually made them Under the European system this is not possible In this country more emphasis is laid upon advertising

the breeder and less upon the educational features of the exhibition than in the European countries. However, the exhibitions in this country have recently been improved in this respect.

Two Classes of Showmen. It is not a difficult problem for a man willing to spend large sums of money (provided he knows the type that wins, or can employ someone who does) to buy a herd of cattle that will win prizes at the shows. Such a man is known as "a fancier." Probably, so far as advertising the breed is concerned, he does as much good as though he were a breeder, but from the standpoint of permanent improvement of the breed he can do it little good. Such a person often disposes of his herd at the close of the show season, and thus no permanent good results.

A more constructive type of showman is the "breeder." The advisability of making it a prerequisite to the showing of animals that they be bred by the exhibitor, or at least that they be in his possession many months, has been considered. The result of such a restriction would be the establishment of more breeding centers upon which the public might depend for animals that would continue to breed true to type. The breeder type of exhibitor is the one that benefits not only himself and his herd but the breed as well. He should be given all the encouragement possible.

Winning Animals. For many years the judges at our fairs have been selected under conditions that warrant their ability to give unbiased decisions and that compel them to be well informed about the desired type of winners. The result is that, within minor degrees of difference, the most desirable animals win today in the show ring. There was a time when breed types were less well known, judges were less carefully selected, and, as a result, the placement was somewhat of a lottery, and animals inferior in type and quality were often placed first. Fortunately, that day is past; no one can now hope to win with cattle, even though they have been well fitted, unless they possess the true breed characteristics. All animals exhibited are supposed to be typical of the breed, and this is as it should be.

Early Preparation of the Show Herd. The man who is going to exhibit his herd on a show circuit should select among his milking animals the prospective winners—those that seem to pos-

sess in the highest degree the desired characteristics of the breed —and give them special attention, as their condition at the time of the show depends largely upon the care which they have received In the first place, it is very desirable to breed the cows so that they will freshen at the right time It is usually best to have them freshen a short time before they are to be exhibited They should not freshen, however, so long in advance of the fair season that their surplus fat has been milked off, so that they will look unduly thin and show lack of capacity and thrift Sometimes animals are bred to freshen while on the fair circuit This is often very satisfactory, as a cow usually looks her best just before and a few weeks after freshening

It is very important, in selecting the young animals for the show circuit, that they be dropped at the right season of the year The classes for young animals in the show ring usually include all animals within a range of 6 months or 1 year in age The young animals should then approach the upper limit rather than the lower one, as the larger animals will always be given a preference over the smaller ones, everything else being equal

It is well to fit several animals of each class that one intends to exhibit, as it is not always possible to determine just how an animal will respond to fitting until after the fitting season is over All animals that are to be exhibited should also be tested for tuberculosis and Bang's disease, as very few fair associations allow cattle to be exhibited without first being tested

Feeding the Show Herd The feeding of show animals is very important if the best results are to be obtained It is not desirable to have dairy animals excessively fat for exhibition purposes It is desirable, however, for all animals to carry a fair amount of flesh, as a very thin animal will be discriminated against The animal that is reduced in flesh will require a longer fitting period than one that is well nourished This fact should be borne in mind when one selects animals for the show ring

Many different grain rations can be used successfully in fitting animals for show In general, such feeds as wheat bran, ground oats, corn meal, and linseed meal make up the larger part of the ration The grain ration should be fed with good mixed hay, silage, and beet pulp Molasses is often fed also The amount of grain to feed will depend upon the size, condition, and in-

dividuality of the animal As a general rule, the cows should be fed all that they will clean up with relish If they are thin in flesh, the amount of corn meal should be increased Linseed meal is a very popular feed for use at this time as it seems to add a gloss to the hair and quality to the hide Toward the end of the fitting period, beet pulp should be substituted for silage, as it is practically impossible to secure silage on the show circuit and it is best to have the animals on the same feed that they will receive during the show period

Horns. The majority of breeders that show Ayrshires, Jerseys, and Guernseys are still leaving the horns on their cattle Many Holstein and Brown Swiss breeders are removing the horns of their animals There is a trend toward dehorning all cattle, including show animals The uniform dairy cattle score card states the following Absence of Horns—An animal that has been cleanly and neatly dehorned, and whose head shows true breed character—no discrimination When horns are retained, it is necessary that they be shapely and well formed in order to make the best appearance

Certain shapes are favored in the different breeds, and it is important that the horns, when they do not develop normally, be trained to grow in the proper shape Special devices have been provided in order to get the desired shape The horns of the Guernsey, Jersey, and Holstein breeds are required to turn in The usual means of accomplishing this is to use a clamp that fastens onto the horns and pulls them together With the Ayrshire breed, on the other hand, it is desired that the horns turn out and up The apparatus for producing this effect may be of several types, each horn may be trained independently by the use of clamps, or both may be trained together by the use of clamps and weights The clamps are fastened to the ends of the horns and pull the horns up and in

It is important that the training of the horns be started early so that they will be trained in sufficient time for the exhibition The horns on Jerseys and Guernseys should be trained while they are calves, and on Ayrshires when the animals are between the ages of 1 and 2 years

Training In order that the cattle may be shown properly in the ring it is essential that they be given good training before

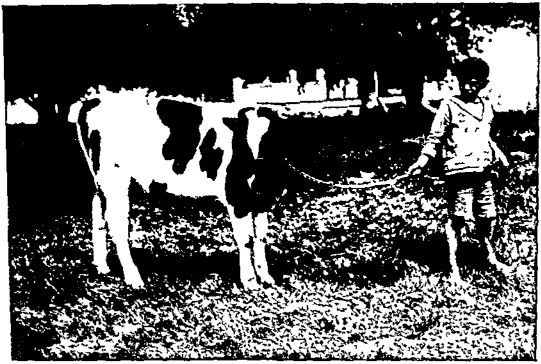

FIG. 43. A poorly trained heifer is difficult to pose.

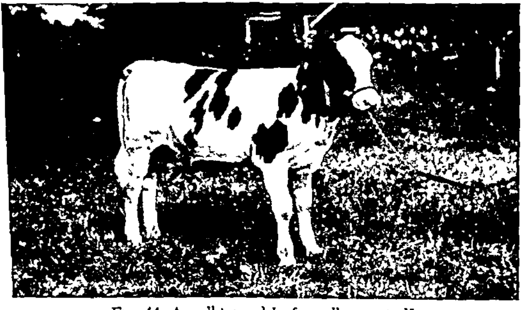

FIG. 44. A well-trained heifer will pose itself.

starting on the circuit Any show animal should lead readily and stand in a position that will display its good points The younger the animal, the more easily it can be taught to lead and stand properly At any age, however, a large amount of time is required to train the animals to lead, back, stand, pose, or change position Many points in posing an animal can be learned only through showing It should be remembered, however, that all the effort expended in fitting an animal may go for naught if it is not properly trained

Clipping The head and tail of all animals are clipped The neck may be clipped in most cases The belly is usually not clipped on heifers, allowing the hair, if not too coarse and ragged, to show a little more depth to the body The belly and udder of the cow are clipped to show quality and to enhance the milk and udder veins

Brushing Brushing stimulates the circulation of the blood and helps make a glossy coat of hair A mellow skin is evidence of good feeding and thorough brushing A soft brush should be used A rubber currycomb is easy on the hide and is an effective tool in getting loose hair and dirt out of the hide The brushes should always be kept clean

Washing The animals should be thoroughly washed with a mild soap such as castile or ivory, and with considerable rubbing All the soap must be rinsed out of the hair After the animals have been thoroughly washed and then kept blanketed, they need to be washed again only enough to keep them clean For the Guernsey and Jersey breeds, where stress is placed on the yellow secretion, washing should be done only at the beginning of the fitting period and when the animals become soiled

Blanketing The animals should be blanketed after washing in order to keep the coat clean and the hide in good condition. Blanketing raises the temperature and retards the hair growth somewhat It helps make the coat smooth and gives an animal a smooth, finished appearance which cannot be obtained otherwise Blanketing of show animals is universally practiced in this country

Polishing Horns and Hoofs The horns and the feet of the animal have an important effect upon its appearance The hoofs of all animals should be carefully trimmed and properly shaped.

This can be done with the use of the chisel, rasp, and pincers. In like manner, the horns should be carefully smoothed and polished. Sometimes metal polish is applied to the horns and they are then rubbed thoroughly until they shine. The feet and horns should be put in shape several months in advance of the show season, so that when the season approaches it will be necessary only to keep them properly polished.

Shipping. The shipping of the animals is an important part of a successful competition on the fair circuit. The herd should be given as much comfort as possible while being moved from one exhibition to another. Usually, a car will be furnished by the railroad, to be used during the entire showing season. It is possible to prepare stalls in the car and to keep them well padded with burlap and bedded with straw so that the animals will be comfortable. The cattle should be carefully blanketed so that they will be protected from all drafts.

The person in charge of the car should provide himself with complete equipment, such as buckets, forks, and shovels, and with the necessary feed. He should be so equipped that he can take care of his animals without assistance from anyone.

Except for long hauls, most cattle are now transported by truck. The same precautions should be observed with the truck as with a railroad car. The protection of the cattle in inclement weather is especially important. Shipping fever is associated with moving or exposure of animals. Some protection can be produced by giving the animal hemorrhagic septicemia vaccine 10 days to 3 weeks before moving them. Hemorrhagic serum can be given 3 or 4 days before the cattle are to be transported. One should always ship a show herd so that they will arrive at the place of exhibition several days before the time of showing. Thus there will then be ample time to get the animals into the best shape before showing.

Final Preparations. When the herd has arrived at the place of exhibition, care should be taken to see that everything has been properly provided. The stalls and pens should be kept clean at all times and a large amount of bedding and feed should be at hand. The entries should be carefully examined to see that they have been properly made out, the rules and methods of the particular fair should be studied and every detail carefully watched

This is particularly true for the beginner, because it may be discovered that on account of some rule an animal will be barred from entering a class.

In order to develop the appearance of great capacity, the animals are sometimes denied water for some hours before being shown. They are given some salt, and then, before going into the ring some water. Being thirsty, they drink a large amount of water and hence should show a somewhat greater capacity than normal.

Bagging Up. Animals in milk are usually brought into the show ring with distended udders. They are generally milked very little the day of the show. The showman may study his cows and know just how many hours are required to "bag up" each cow to show her udder to best advantage. Some quarters may not be completely milked out at that time in order to even up the udder. After this final milking the udder and teats should not be handled. This would cause the cow to let down her milk and cause the udder and teats to strut. Some exhibitors use collodion on the ends of the teats to keep them from leaking. Care should be taken that the cow is not bagged too much. Many cows look better when the udder is not too much distended.

Showing. At the call of the class, the attendant should lead the animal into the ring with an attractive, properly fitting halter. It is the better practice to lead the animal, holding the halter strap in the left hand and to walk backward. From the time the animal enters the ring it should be the business of the attendant to see that it is exhibiting itself to the best advantage at all times.

The exhibitor should keep his eye on the animal and the judge, and should pose his animal even though the judge is not looking at the moment. By a gentle pull or push on the halter it should be possible, by previous training, to pose the animal properly at all times. The importance of proper training is in evidence at this time.

When the placings have been made the animals should be taken from the ring without a word, even though the placement has not been to the liking of the exhibitor. To be a good showman, a man must first learn to be a good loser.

Showing out of the Ring. Breeders are appreciating more and more the value of showing the animals when they are not in the ring. There are always prospective buyers or men who are attending the shows to determine the breed of cattle they wish to develop. It is important, therefore, that such men have an opportunity to see the animals outside the ring. This is especially true of the winning animals. It is usually profitable to have a good showman and salesman with the animals at all times when visitors are about. Unless the animals are about to be shown, the attendant should be willing to remove the blanket and show them at any time.

Classification of Herds. Many breeders find it impractical, or at least undesirable, to exhibit their animals at the leading shows, and hence have no opportunity to measure the type of their herds. The five major breeds associations, realizing that the improvement of their breeds depends not only upon their production but also upon the type of the animals, have adopted plans of inspection and classification of cattle. The animals in the herd are classified by a reputable judge and are put in various classifications, such as: excellent, very good, good plus (desirable), good (acceptable), fair, and poor, according as they meet the requirements of the score card.

This program *does more for the individual herd than does* the show ring, as far as evaluating type is concerned. All females that have ever freshened are classified; therefore, it gives the owner the rating on all his cows. Also, he gets a rating on each part of the animal. He may study the results and learn where the weak and strong points are in his herd as a whole (see Chapter 28, on breed-association programs).

REFERENCES FOR FURTHER STUDY

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2. R. C. Klussendorf, The Technique of Fitting and Showing, *Guern. Br. J.* (July 15 and Aug 1, 1947).
3. Spearing, *Fitting and Showing Dairy Cattle,* 1952.

32

Production of High-Quality Milk

With the proper barn and equipment, as described in later chapters, it should not be a difficult task to produce high grade milk. The equipment, however, is not all that must be considered in this connection. Proper methods must also be followed if the best results are to be obtained. In fact, high grade milk may be produced in very ordinary barns and with mediocre equipment, if the methods are good. In order to produce clean, high quality milk, the dairyman must understand what constitutes cleanliness and be willing to watch all details that are necessary for the production of such milk.

Milk is easily contaminated with dirt, bacteria, and odors. Milk furnishes an excellent medium for the growth of bacteria, particularly when not properly cooled. Great care is necessary in the production and handling of milk as a food product, in order to put it in the hands of the consumer in satisfactory condition.

PRODUCING HIGH QUALITY MILK

Milk, to be high grade, must be clean and of good flavor and contain a minimum of bacteria, none of which should be harmful. In order to produce such milk, very careful methods have been devised. These methods do not require elaborate or expensive equipment but they do require great care and cleanliness.

Healthy Cows. Milk should be produced from cows known to be free from disease. As stated in a previous chapter, tuberculosis in dairy cows, especially when the udder is infected, may be the cause of tuberculosis in humans, and Brucellosis or un-

dulant fever may be caused by the consumption of milk from cows with Brucellosis Cows should be tested for tuberculosis and Brucellosis at least once a year, and if the disease is found, the test should be made more frequently All reacting animals should be removed from the herd and the stables and premises thoroughly disinfected

Milk that is in any way abnormal should be discarded As a general rule, milk from a cow 2 weeks before calving or 4 days

FIG 45 Clean, healthy cows coming from pasture to be milked (*W Va Univ*)

after calving should not be used Only milk from healthy, normal cows should be used Milk from cows that are affected with mastitis is often abnormal chemically and physically and usually has a high bacteria count

The use of antibiotics in the treatment of mastitis has proved effective, however, the milk produced for several days after treatment contains some of the antibiotics Such milk causes difficulty in cheese making and in the manufacture of cultured buttermilk or churning Studies made at the Florida and Virginia Experiment Stations * showed that milk from cows treated with penicillin or aureomycin should not be used for a period of 72 hours following treatment

Clean Cows Much of the dirt and dust that gets into the milk comes from the cow's flanks udder, or belly during milking time For this reason the cows should be cleaned before they are milked The amount of labor required to keep a cow clean is

* *J Dairy Sci* (July, 1951), and *Sou Agr Work* (1950)

lessened by having the stall platform the right length, by using sufficient bedding, and by keeping the hair clipped from the udder, flanks, and the belly Long hairs that drop into the milk carry with them large numbers of bacteria Dust also is removed from the cow with greater difficulty if long hair is present on the parts mentioned When kept in the barn, the cows should be given at least one complete grooming daily This should be done long enough before milking so that there will be time for the dust to settle

The udder and teats should be washed immediately before milking The wash water should contain a disinfecting solution Chlorine (solution of 200 parts per million) has been the standard chemical for this use for many years Also, a number of quaternary ammonium compounds have been used In trials at the Virginia Station involving a number of these compounds it was found that they were equally as effective as chlorine in reducing the number of bacteria on the udder and teats The use of either chlorine or quaternary compounds reduced the number of bacteria on the surface of the udder and teats approximately 80 per cent.

The quaternary compounds have the desirable quality of not chapping or irritating the hands of the user and the teats of the cows as much as chlorine This is a special advantage when washing the udders with hot water during cold weather A clean cloth or towel should be used for washing the udder It is desirable to use a different towel for each cow Because of the difficulty of keeping a supply of clean and dry cloths, some dairymen are using disposable paper towels made especially for this purpose The value of washing the udder to reduce the bacteria count is shown in Table LXXVI *

Milk always contains some bacteria when drawn from the cow The number of bacteria found in the udders of different cows varies considerably In studies by Sherman † on udder flora, it was found that certain cows produced milk containing not more than 300 or 400 bacteria per cubic centimeter, whereas in the milk from others, the count did not go below 20 000 or more

* *Rept on Milk Contamination* Orr

† Unpublished data Pa. Exp Sta.

TABLE LXXVI

EFFECT OF BRUSHING, WASHING, AND DRYING OF COW'S UDDER AND FLANKS ON BACTERIA COUNT

Housing of Cows	Condition of Cows	Number of Experiments	Average Plate Count
Summer—all cows out	Untouched	7	440
Summer—all cows out	Udder and flanks washed and brushed	3	170
Winter—cows indoors	Untouched	3	4752
Winter—cows indoors	Udder and flanks brushed	3	1752
Winter—cows indoors	Udder and flanks brushed, washed, and left moist	6	230
Winter—cows indoors	Udder and flanks brushed, washed and dried	3	440

This may possibly be caused by the fact that the opening of some teats is larger than that of others, or that the sphincter muscle of the teats closes imperfectly, allowing a greater number of bacteria to enter the udder. Also, udder trouble, such as mastitis, results in many bacteria being given off in the milk. Some cows may have chronic udder trouble, which is not generally noticeable, but which causes them to give off large numbers of bacteria. Whatever the cause, it is necessary in the production of the highest grade of milk to make a study of the individual cows and to correct the cause, or to eliminate those that constantly produce milk containing many bacteria. As there are slightly more bacteria in the milk first drawn than in that drawn later, it is the practice of some dairymen to discard the first few streams from each teat. This practice fits well with the use of a strip cup as a control measure for mastitis.

Clean Barns. Whenever possible, the barn should be located on high ground with good natural drainage and at a good distance from poultry houses, hog pens, manure piles, or other surroundings that might pollute the barn air and furnish breeding grounds for flies.

The floor of the barn should be nonabsorbent and smooth so that it can be easily cleaned. Drains should be provided so that the floors and walls can be washed. The stalls and mangers should be such that they offer the least surface for collecting

dust and dirt and the least obstruction to the circulation of air. Good ventilation should be provided so that the air will be kept pure and clean, both for the health of the cows and to prevent odors being taken up by the milk. Too much light cannot be provided; *bacteria do not thrive in brightly lighted places, especially in sunlight.* The light not only shows the presence of any dirt but also helps to keep the barn in a sweet condition.

Fig. 46. Plates exposed to the air of a stable. The plate on the left was exposed 5 minutes and the one on the right for 10 minutes (*Trout*).

The stable air should be kept clean. Dust carries bacteria, hence it is necessary in the production of clean milk to have the barn as free from dust as possible. Feeds containing dust should not be fed for some time before milking, nor should dusty bedding be used. *Figures 46 and and 47* * *show the effect of dust in the stable air. Figure 46 shows agar plates exposed to the air of a stable for 5 and 10 minutes, and Fig. 47 shows agar plates exposed to the air of the same stable for 5 and 10 minutes just after hay had been put down the chute.* Studies by several experimenters † seem to indicate that the methods of management and air control as generally practiced in well-managed dairies have less influence upon the number of bacteria contained in the milk than was formerly believed.

Care should be taken in the feeding of cows to protect the milk

* W. Va *Exp Sta. Circ.* 43.

† Thesis, Etters, Pa. Exp. Sta.; N. Y. (*Geneva*) *Exp. Sta. Bul.* 409.

from contamination, both while it is being drawn and after it has been drawn. Certain feeds impart a good flavor to milk and others give an objectionable flavor. None of the feeds with strong odors, such as turnips or silage, should be fed immediately before or during milking.

Clean Milker. The methods of the milker are important in the production of clean milk. A man who is clean in his milking

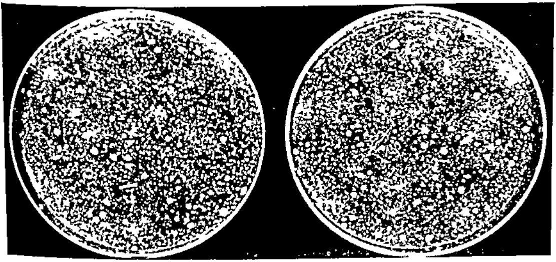

FIG. 47. Plates exposed to the air of the same stable as those in Fig. 46, but just after hay had been put down the chute. The large number of colonies of bacteria indicate the presence of enormous numbers of bacteria on hay dust. The plate on the left was exposed 5 minutes and the one on the right 10 minutes (*Trout*).

operations can produce high-grade milk in almost any barn, whereas the careless milker cannot produce good milk under the best barn conditions.

The milker should be healthy, and should avoid exposure to communicable diseases. When a high-grade milk is being produced, especially if it is not pasteurized before consumption, it is desirable that the men doing the milking be examined for evidence of septic sore throat, typhoid, or other diseases, because apparently healthy people may be carriers of certain disease germs.

The milker should take special care of his hands and should always milk with clean, dry hands. If the teats are hard and dry and it seems necessary to moisten them, a small quantity of lanolin may be applied after they have been washed. The milking

should be done quickly and thoroughly Clean clothes should always be worn by milkers

Small-Top Milk Pails Since a large part of the dirt found in milk falls from the body of the cow into the pail at milking time, the advantage of a small top milk pail is obvious The use of such a pail results in a cleaner milk and a lower bacteria count, because it keeps much of the dirt from getting into the milk In a study of the effect of a covered pail in a stable where but little attention is given to cleanliness, the Connecticut Experiment Station * obtained the results shown in Table LXXVII A small-

TABLE LXXVII

EFFECT OF COVERED PAIL IN STABLE WHERE BUT LITTLE CARE IS GIVEN TO CLEANLINESS

Number of Experiment	Total Bacteria	Acid Bacteria	Liquefying Bacteria
A Open Pail			
1	811,900	761 660	23,790
2	9,100,000	9 087,900	4,160
3	3,113,000	2 025 000	26,660
4	3,025 000	314 600	30,000
5	4,470,000	2 443 000	26,660
6	115 400	21 040	10,000
Average	3,439,200	2,442 200	18,550
B Pail with Cover			
1	19 790	13,330	0
2	219 160	189 800	0
3	64 580	27 000	14 580
4	90 000	32 000	4,000
5	220 800	81,600	15,830
6	7,250	3 500	166
Average	103,600	57,800	5,760

top pail may seem awkward at first but with a little practice a milker will find it quite satisfactory

Handling the Milk The milk should be removed to the milk house immediately after it is drawn Contamination may take

* Storrs (*Conn*) *Exp Sta Bul* 48

place if it is left in the barn. Milk readily absorbs the odors of the stable.

The milk should then be strained into cans. If the cows are carefully milked the straining should not be necessary. It is impossible to strain bacteria out of milk. However, it is usually desirable to strain the milk in order to remove any hairs or particles of bedding or feed that may have dropped into it. The strainer should be of the single-service-pad type, and a clean pad should be used at each milking. This will remove more of the sediment than the wire-gauze or cloth type of strainer, both of which are difficult to clean and sterilize and thus cause more work and poorer quality of milk.

Cooling the Milk. Proper cooling is one of the essential factors in the production of high-grade milk. Even though milk has been carefully produced, it will contain a large number of bacteria when it reaches the consumer unless it is properly cooled and held at a low temperature until it is delivered. It is impossible to produce milk without some bacteria; the point to observe is to prevent the multiplication of the bacteria that have gained access. If the temperature is held below 50°F. the increase in the number of bacteria will be slow; whereas a temperature much above 50°F. will cause them to increase rapidly. Table LXXVIII shows the importance of keeping milk cool.*

TABLE LXXVIII

Effects of Varying Temperatures upon the Bacteria Growth in Milk

Temperature Maintained for 12 Hours, °F.	Bacteria per cc. at End of 12 Hours
40	4,000
47	9,000
50	18,000
55	38,000
60	453,000
70	8,800,000
80	55,300,000

There are various means of cooling milk. When the milk is sold for manufacturing purposes and the restrictions on tempera-

* *N. Y. Dept. Agr. Circ.* 10.

ture and bacteria counts are less strict, the cooling may be taken care of by immersing the cans of milk in a tank of spring or well water

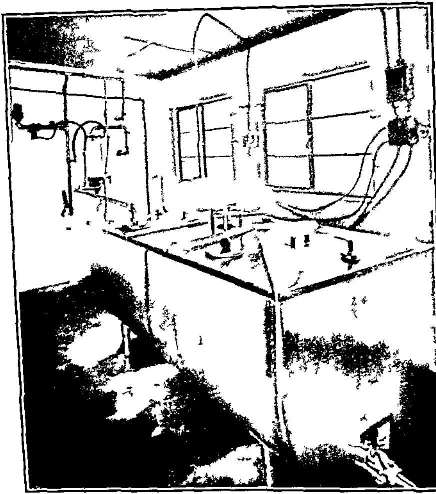

FIG 48 Cold wall milk-cooling tank (*Mojonnier Bros*)

When milk is to be used as market milk with a low tempera ture and a low bacteria count required it is necessary to have a mechanical cooler The simplest of these is a wet storage box, where the cans of milk are set in the water cooled by refrigera tion This system may be modified by pumping the precooled water through an aerator and cooling the milk before it is stored

in the wet storage. The precooled milk may also be stored in a cold air or walk-in type dry storage.

The cold-wall tank is the latest development in milk cooling It is a stainless-steel refrigerated tank The milk is poured directly into it instead of into cans When the pipeline system of milking is used the milk goes directly from the udder of the cow through sanitary pipes to the tank The milk is then pumped into a tank truck for delivery to the milk plant, or it may be run directly into cans for delivery.

Utensils. It is important that the dairy utensils be seamless or constructed with smooth, filled joints and corners so that they may easily be kept in good condition Rusty tinware should not be used One of the most common sources of contamination of milk is the utensils In one experiment, milk drawn into sterilized pails had an average bacterial count of only 6306 per cubic centimeter, whereas samples from a pail that had not been sterilized contained, on an average, 73,308 bacteria per cubic centimeter Even when the utensils are well washed and presumably well cleaned, bacteria may exist and increase very rapidly in them

Utensils should first be washed with lukewarm water, then with hot water and a detergent that includes a wetting agent, not soap They should then be rinsed and sterilized Utensils should be sterilized by exposing the utensils to steam for several minutes by placing them in a sterilizer under pressure or by using a chlorine solution A rinse with chlorine solution just before use is a recommended practice The effect of sterilization of dairy utensils is shown in Table LXXIX

Milking Machines. High quality milk can be produced with milking machines There is little opportunity for any extraneous material to get into the milk if the udder and teats are washed and the teat cups are handled with care When the milker unit, including all parts that the milk comes into contact with, is thoroughly cleaned and sterilized, milk with low bacteria count can be produced However, without such precaution the milker unit can be one of the greatest sources of contamination

Cleaning and Sterilizing Milking Machines A milking machine should first be rinsed in lukewarm water and then washed thoroughly and sterilized It may be disassembled and washed in the same manner as the other utensils and reassembled just

Gallons delivered daily

to plant ______

Whole Milk ______

MILK PRODUCER INSPECTION FORM

______
(City, county, or district)

NAME ______ LOCATION ______

SIR An inspection of your dairy has this day been made and you are notified of the defects marked below with a cross (X) Violation of the same item on two successive inspections is justification for degrading

COWS

Item No

(1) Tuberculosis and other diseases —Annual Tuberculin test ( ) Certificate of test on file ( ) Other tests as required ( ), no cows with extensive induration of udder ( ) no cows giving abnormal milk ( ) ( )

DAIRY BARN

(2) Lighting milking barn —Adequate light openings ( ), windows clean adequate artificial light for night milking ( ) ( )

(3) Air space and ventilation —Well ventilated ( ), no overcrowding ( ) ( )

(4a) Floor construction milking barn —Floors and gutters concrete or other impervious and easily cleaned material in good repair ( ) graded to drain ( ) ( )

(4b) Floor cleanliness, milking barn —No accumulation beyond one milking ( ) no horses pigs fowl calves etc., ( ) No feed stored in milking section of barn ( ) ( )

(5) Walls and ceilings —Painted or other satisfactory finish ( ) clean smooth and in good repair ( ) ceiling tight if feedstuffs over ( ) feedroom partitioned dust tight with door ( ) ( )

(6a) Cowyard grading and draining —Graded ( ), drained ( ) no pooled wastes ( ) properly fenced ( ) proper entrance lane ( )

(6b) Cowyard Cleanliness —Clean ( ) no swine ( ) ( )

TOILET

Item No

(10) Toilet — Conveniently located ( ) clean ( ) constructed and operated according to Code ( ), no evidence of defecation or urination about premises ( ) ( )

WATER SUPPLY

(11) Water supply —Easily accessible ( ), adequate ( ), safe, no surface or cistern water unless approved ( ) sanitary quality (see Code) ( ), ( )

UTENSILS

(12) Construction —Smooth heavy gage material ( ) Corrosion proof surface no agateware ( ), easily cleanable shape ( ) joints soldered flush ( ) good repair ( ) no woven wire cloth ( ), milk pails small mouth design ( ) single service filters ( ) ( )

(13) Cleaning —Cleaned after each usage ( ) must look and feel clean ( ) ( )

(14) Bactericidal treatment —Steam cabinet 170° F for 15 minutes or 200° F for 5 minutes or steam jet for 1 minute, or immersed in approved sanitizing solution or 170° F water for 2 minutes or flow of approved sanitizing solution or 170° F water at outlet for 5 minutes or hot air cabinet 180° F for 20 minutes ( ), cabinets have thermometer in coldest zone ( ), ( )

(7) *Manure disposal.*—*Stored inaccessible to cows, 50 feet from barn and, during fly season: (a) Spread on fields, or (b) piled not more than 4 days and then spread, or (c) stored not more than 7 days in impervious bin or curbed platform and then spread, or (d) stored in tight, screened, and trapped manure shed, or (e) fly breeding minimized by other approved methods* . . . . ( )

MILK HOUSE

(8a) **Floors.**—Smooth concrete or other impervious material ( ), graded to drain ( ) . . . . ( )

(8b) **Walls and ceilings.**—Smooth dressed lumber, sheet metal, or plasterboard, well painted with washable paint, hollow tile, cement blocks, bricks, concrete, or cement plaster, surfaces and joints smooth . . . . ( )

(8c) **Lighting and ventilation.**—Effective window area at least 10 per cent of floor area ( ), adequate artificial lighting (see Code) ( ), adequate ventilation ( ), doors and windows closed during dusty weather ( ) . . . . . . ( )

(8d) **Screening.**—All openings effectively screened and doors open outward and self closing, unless flies otherwise kept out ( )

(8e) **Miscellaneous requirements.**—Used for milk purposes only, except by permission ( ), milk house operations not conducted elsewhere ( ), no direct opening into living quarters or stable ( ), piped water ( ), wastes properly disposed of ( ), 2-compartment stationary wash and rinse vats, adequate water heating facilities ( )

(9) **Cleanliness and flies.**—Floors, walls, windows, shelves, tables, and equipment clean ( ), no trash or unnecessary articles ( ), all necessary fly control methods ( ), is "Notification of Disease" placard posted ( ) . . . . . ( )

(15) *Storage.*—*Left in treating chamber until used or stored inverted on metal racks above floor in milk house ( ), ( ), filters shall be properly stored ( ),* . . . . ( )

(16) *Handling.*—*After bactericidal treatment no handling of surfaces to which milk is exposed* . . . . ( )

MILKING

(17) **Udder and teats.**—Clean and rinsed with approved sanitizing solution at time of milking ( ), abnormal milk excluded ( ), ... ( )

(18) **Flanks.**—Flanks, bellies and tails free from visible dirt at time of milking ( ), brushing completed before milking begun ( ), clipped ( ), ... ( )

(19) **Milker's hands.**—Clean ( ), rinsed in approved sanitizing solution just before milking each cow ( ), dry while milking ( ), hand-washing facilities including soap, water, and individual clean towels convenient to milking barn ( ), ... ( )

(20) **Clothing.**—Clean outer garments . . . . ( )

(21) **Milk stools.**—Clean, not padded ( ), stored above floor ( ), ... ( )

(22) **Removal of milk.**—Immediate removal of milk to milk house or straining room ( ), no straining in barn ( ), milk containers covered ( ), ... ( )

(23) **Cooling.**—Milk cooled immediately after milking to 60° F. or lower and so maintained until delivery to plants . . . . ( )

MISCELLANEOUS

(26) **Vehicles.**—Clean ( ), no contaminating substances transported ( ), milk covered in transit ( ), **Premises.**—Surroundings kept neat and clean ( ), ... ( )

Date____________________ ____________________, *Inspector.*

examine the milk itself, as it reaches the market, by means of acid tests reductase tests sediment tests or bacteria counts Some times two or more of these tests are combined

The second method of inspection consists of an examination of the conditions on the farm Such factors as the health of the cows the condition of the stable and the methods used are taken into consideration Many cities employ a combination of the two systems

Examination of the Milk *Milk that contains considerable* sediment as indicated by the sediment tester, shows plainly that it has been produced under unclean conditions The acid test and the reductase test may indicate the age of the milk rather than its cleanliness The presence of a large number of bac teria may be due to the age of the milk poor cooling or to the number of bacteria in the milk when it was drawn from the cow A small number of bacteria in raw milk however indicates that the milk has been produced under clean conditions and properly cooled The number of bacteria found in a sample of raw milk depends upon three factors the number of bacteria in the udder at the time the milk was drawn the number that have gained access to the milk since it was drawn and the amount of growth or increase that has taken place previous to the examination If milk is properly produced and carefully handled it should contain relatively few bacteria even though it is held for some time before being put on the market

Examination of the Conditions at the Farm When the condi tions at the farm are examined they are usually rated by means of an inspection form (page 524) It will be noted that the in spection includes both the equipment and the methods The in spection form is useful in indicating the various points to be con sidered in the production of high grade milk The inspection form in this way not only serves as a guide for the inspector but also indicates to the dairyman the improvements needed in his barn milk house equipment, and methods in order to produce clean wholesome milk

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5 Dahlberg and Marquardt, Sterilization of Dairy Farm Utensils with Dry Heat, *N Y (Geneva) Exp Sta Bul* 612 (1932)
6 Marquardt and Dahlberg, Electric Cooling of Milk on the Farm, *N Y (Geneva) Exp Sta Bul* 581 (1930)

33

Marketing Milk

The marketing of milk and milk products is, from the financial point of view, of the greatest importance. Successful operation of many farms is dependent upon the income from the milk sold, particularly when dairying is the major enterprise. In some localities only one method of disposing of the milk is available, whereas in others the producers may have a choice of several methods. The kind of market to which the milk is sold determines the quality requirements.

Fluid Milk. The largest market for milk, especially in the eastern states, is milk for consumption mainly as fluid milk. Such milk must be of the highest quality and produced under the supervision of health authorities. The majority of such milk is sold from the farm to the milk plant for processing and distributing to the consumer. A small amount still is delivered from the farm direct to the consumer. This latter method is referred to as the producer distributor system. It is rapidly being absorbed by city plants. Milk produced and sold retail obtains a considerably higher price than milk sold for manufacturing purposes.

Manufacturing Milk. In a great many areas whole milk is sold for manufacturing purposes. Milk used in the manufacture of dairy products should be clean and sweet when delivered. The sanitary requirements for such milk usually are not so stringent as for milk sold for bottling. The main outlets for manufacturing milk are ice cream and milk powder plants, condenseries, cheese factories and creameries.

Sour Cream. Where the above markets are not available or the farmer does not choose to go to the expense or effort to produce such milk he may separate his milk at the farm and sell sour cream to a creamery. The sour cream producer is usually a

farmer who keeps only a few cows Sour cream need not be delivered oftener than 2 or 3 times per week The skim milk can be used to good advantage on the farm for feeding calves, poultry, and swine In the past, a large amount of butter was made on the farm for sale or for home use This practice has declined and the output now is relatively small

USE OF MILK

The total milk production in the United States * for 1950 was 57,387 million quarts, with a value of $3,763,459,000 The portion of the milk used for various purposes was

	Per Cent
Fluid Milk used in cities and villages	37 3
used on farms	10 1
Butter creamery	22 7
farm	4 3
Cheese	9 5
Evaporated and condensed milk	5 6
Powdered whole milk	0 8
Ice cream	5 1
Fed calves on farms	2 7
Other uses	1 9

METHODS OF SELLING MARKET MILK

Producer Distributor A small amount of milk still is being sold by the producer directly to the consumer The distribution of milk is a business itself, separate from that of milk production The milk must be bottled and often pasteurized The consumer price is received by the dairyman in this method but there is the additional expense of equipment, bottles bottling the milk, cleaning the bottles, delivery of the milk, and collecting for it These additional costs and the necessity of more labor have caused most producer distributors to drop the delivery portion of their business and to sell milk wholesale to a milk plant

Wholesale to Distributor Milk is usually sold to the distributor s plant or receiving stations In most cases the milk is

* *U S Census Rept*, 1950

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	Per Cent
Fluid Milk: used in cities and villages	37.3
used on farms	10.1
Butter: creamery	22.7
farm	4.3
Cheese	9.5
Evaporated and condensed milk	5.6
Powdered whole milk	0.8
Ice cream	5.1
Fed calves on farms	2.7
Other uses	1.9

METHODS OF SELLING MARKET MILK

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Wholesale to Distributor. Milk is usually sold to the distributor's plant or receiving stations. In most cases the milk is

* *U. S. Census Rept.*, 1950.

picked up at the farmer s milk house and delivered to the plant by a plant truck or an independent contract hauler, and the cost of hauling is deducted from the price of milk

Selling the Milk for the Fluid Milk Market

Dairymen sometimes make their own contract with the milk distributor This method is more common with small plants, but is decreasing in practice Often especially in the larger milk sheds the dairymen are organized into a milk producers' cooperative The purpose of such organizations usually is not to actually handle the milk but to serve as bargaining associations in selling milk collectively to the distributors In fewer instances, the co operative operates a plant and processes and distributes the mem bers milk

Methods of Paying for Fluid Milk

Milk marketing is a complicated business because milk is a perishable product both the supply and demand are variable and the milk supply ultimately goes into many different uses Various methods of paying for market milk have been developed such as the following

(1) **Base Surplus Plan** The amount of milk produced in most milk sheds is greater during the spring months and lower during the fall months In order to compensate the dairyman who main tains a high fall production when more milk is needed many markets operate on the base surplus plan The base period is established during the lower production months using a period of 3 to 6 months A dairyman s base is established by the aver age amount of milk delivered during the base period His base may be modified in future years if production during the base making months is changed This encourages the dairyman to produce a more uniform supply throughout the year A dairy man s base figured as a certain percentage of all bases on a spe cific market indicates his portion of the total market Milk de livered in excess of the allotted base amount is paid for on the surplus milk value

(2) **Milk-Use Basis.** Payment for milk on the basis for which it is used is generally a part of the milk-pricing structure The milk bottled as whole milk or sweet cream is paid for at the highest price, and usually is referred to as Class I milk The milk used for ice-cream manufacture and condensed milk is paid for at a lower price and is called Class II milk All other milk is called Class III milk and is used largely for butter or cheese This milk is the lowest-priced milk

Under this system the same quality milk is paid for at three different levels of prices The system is a fair one, however, for both the distributor and producer if the three prices are arrived at fairly and correctly for that market The producer is assured of receiving the highest price for all the milk that is sold as bottled milk or cream The distributor, on the other hand, can afford to pay the higher price for all the milk sold as bottled milk since he gets the remainder of the milk at a price consistent with the use that he can make of it A combination of the base surplus and the milk-use systems appears to be a rather complicated method of payment for milk, but it is workable and used in many markets

(3) **Take-Off and Pay-Back Plan.** The base-surplus method is helpful in many markets in leveling out production throughout the year In some markets other methods appear to be more satisfactory and to get results in a shorter period of time One market that had its lowest production in November and the highest production in May over a period of years, established the following system A deduction of 50 cents per 100 pounds of milk is made for all milk delivered in April The total amount deducted is held in a fund and added to the price paid for milk delivered in October Since there is less milk delivered in October than in April, the amount added to the October price is greater than 50 cents per 100 pounds Likewise, 75 cents per 100 pounds is deducted from the May milk and added to the price of the November milk, and a 50 cents deduction from the June milk is added on to the December milk This method has brought the supply of milk quite close to the demand for it

Butterfat Test and Price The butterfat test of milk is another factor that affects the price The common practice is to establish a price per 100 pounds of milk with a specified butter-

fat test Four per cent butterfat is the usual basis for pricing, however several markets have established their base at as low as 3 5 per cent butterfat There is a tendency to have this base as near as possible to the general average of the milk sold in the market A price differential is set up for milk testing above or below this amount The differential is a certain number of cents for each 0 1 per cent butterfat variation

If the established price is $5 00 per 100 pounds of 4 per cent milk with an 8 cent butterfat differential milk testing 4 5 per cent would sell for $5 40 per 100 pounds and 3 5 per cent milk would sell for $4 60 per 100 pounds This differential varies in different markets

Gallon or Quart Basis Occasionally a producer supplies milk to a distributor on a per gallon or per quart basis This method is used by only a few small distributors As average milk weighs 2 15 pounds to the quart and 8 6 pounds to the gal lon 100 pounds of milk would be equivalent to 46 5 quarts or 11 6 gallons These figures may be used to compare the returns for selling milk by different methods

Special Milks Some milk is produced and sold as special milk which commands an increased price Certified milk is pro duced under special sanitary conditions prescribed by the Ameri can Association of Medical Milk Commission and is usually sold at a higher price than ordinary milk

Golden Guernsey milk is produced by purebred Guernsey herds that comply with the regulations of the American Guernsey Cattle Club and is sold under the Golden Guernsey" trademark at a premium of a few cents per quart above regular milk

Jersey Creamline milk is produced by purebred Jersey herds that comply with the regulations of the American Jersey Cattle Club and is sold at an advanced price as "Jersey Creamline" milk and also with the trademark JerZ

Premiums for Quality In a few markets premiums are payed for milk that meets certain quality standards such as a high barn score and low bacteria counts

MILK CONTROL BOARDS

Several states have milk control boards or milk commissions that have the power to establish the price of milk to the producer

and consumer. They also are charged with licensing producers and distributors. The purpose of these boards is to assure the producer fair prices and fair trade practices which, in turn, provide good assurance to the consumer that an adequate supply of high-quality milk will be furnished. There is also a federal milk-marketing law that may operate in establishing prices where the market is organized under this law.

SELLING MILK FOR MANUFACTURING PURPOSES

Milk for manufacturing purposes is sold for a lower price than market milk. It can be produced somewhat cheaper since there is not the necessity for adhering to such strict regulations of milk ordinances, and there is usually no surplus problem. Neither is there the same necessity for a uniform production throughout the year, even though this would be desirable.

Plants using milk for the manufacture of dairy products are usually located away from large centers of population so that they will not be competing with market-milk distributors.

The majority of the milk produced primarily for this purpose comes from farmers with fewer cows and more limited facilities than grade A producers. Many of these farmers, if properly located, are building up their herds and facilities so that ultimately they may sell their milk for use as market milk.

Condenseries and Powder Plants. Milk plants that condense or powder the milk utilize all of the solids of the milk. The price is usually based on a formula which takes into account the price of butter and of the nonfat milk solids. The price is quoted to the farmer as a certain amount for 4 per cent milk (or some other base) with a stated fat differential.

Cheese Factories. In the manufacture of cheese, some of the milk solids remain in the whey. Whey contains most of the lactose, albumin, minerals, and some of the fat. Whey has some value commercially. It also has some feeding value, either in the liquid form or as dried whey. The whey may be returned to the producer for livestock feeding.

The price of milk for cheesemaking is based on the price of cheese. The price is usually stated on a 100 pounds of standard test milk with a fat differential. On the average, about 10

pounds of cheese can be made from 100 pounds of 4 per cent milk

Selling Sweet Cream Some dairymen are so situated that they can sell sweet cream to ice cream manufacturers or for making sweet cream butter Sweet cream may be sold on the basis of the pounds of fat that it contains or at a stated price per gallon of cream of a certain test Single cream, also called coffee cream contains 18 per cent fat Whipping cream or double cream, usually contains 35 or more per cent of fat

TABLE LXXX

Weight of Cream

Per Cent of Fat in Cream	Specific Gravity of Cream	Weight per Gallon of Cream pounds
0	1 036	8 64
10	1 024	8 54
20	1 013	8 45
30	1 002	8 35
40	0 991	8 26
50	0 980	8 17
60	0 970	8 09

Selling Sour Cream The selling of sour cream for creamery butter making usually results in the smallest cash return of any method of selling milk Of course the skim milk is left on the farm for feeding Sour cream is sold on the basis of the pounds of fat that it contains The price of fat is based on the butter market Farmers just starting in the dairy business often market sour cream and later switch to the marketing of whole milk

REFERENCES FOR FURTHER STUDY

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4 Cotton Consumption of Dairy Products in North Carolina--Urban--Rural *N C Exp Sta Buls* 371 and 372 (1950)
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Dairy Buildings. Types and Arrangements

The dairy barn and milk house, more than any other buildings on the farm, require special and somewhat specific details of arrangements and construction In the first place, they must conform to the requirements of the health authorities, who require buildings where clean and safe milk can be produced In the second place, the barn should be comfortable and healthful for the animals, and finally, they must be so arranged that the work can be done in the shortest time and with the least expenditure of energy

The future dairy barn will probably be vastly different from the conventional ones that have been common in the past This is true for several reasons First, the cost of building has increased so greatly that most dairymen cannot afford to build the kind of barns that have been built in the past Second, greater consideration must be given to the conservation of labor, and, as a result, many features will be incorporated that have not been used in the past Third, the new methods of harvesting and storing crops call for a new and different type of storage in dairy barns, especially for the roughages Just what the conventional type of barn will be in the future is speculative, but it is certain to be different from the one in the past In fact, the change has already started

Location. The barn should always be on an elevated area where there will be good drainage away from the barn However, on account of the cold winds and the occasional difficulty of securing sufficient level area for all of the needed buildings, this is not always possible Good drainage and healthful surroundings are of first importance in the location of a dairy barn Of course, it is essential that a good supply of fresh water be available.

Grouping the Buildings *All the dairy farm structures must be* considered in planning the location and general layout of the buildings The location of the barn must be related to the cropland, the pastureland, the farmhouse, and the roads and lanes

The farmhouse will usually be given the most prominent location and the most attractive view It is usually the building nearest the highway but if it is a main highway with heavy traffic, the house should be located several hundred feet from it The barn and other farm buildings may be located in the rear of or to the side of the house, at least 100 feet away from the house The area between the house and barn, called the service area, *should be free from fences and gates, no animals should be allowed* The milk house should be located on the side of the barn next to the service area The other buildings may be grouped around this area or may be located away from the main barn

Cow Lots and Lanes Several lots should be provided, one of which should be near the barn in which the cows can be turned each day during the winter months when they are for the most part confined to the barn Unless the lots open directly into the pastures, a lane must be provided to get the cows to and from pasture This lane should be well drained to keep it as free from mud and mire as possible The barn lot itself should be paved, either with concrete, with an asphalt gravel mixture, or with a fill of stones and rocks rolled to a tight, smooth surface It should be kept as free of mud as possible

The roads from the barn to the main road and to the fields are important and should be stoned or graveled and kept in good shape Since the feed and bedding that must be hauled to the barn each year averages between 6 and 10 tons per cow and from 8 to 10 tons of manure per cow must be hauled from the barn, it is important that these farm roads be given attention These roads must be used in all kinds of weather, often when the ground is wet and soft

Types of Dairy Barns Two general types of dairy barns are in general use at the present time the conventional dairy barn and the loose housing barn in combination with some type of milking barn or parlor Each type has advantages and disadvantages Requirements of the health authorities, cost of

construction, labor-saving features, and custom influence the type of barn that will be built.

THE CONVENTIONAL DAIRY BARN

The conventional dairy barn is a rectangular barn of either one- or two-story construction. A one-row arrangement can be used if the herd is small, but if more than ten stalls are required, two rows are preferable from the standpoint of convenience, space required, and cost. More than two rows are objectionable because there must be many posts to support the floor or roof, and there is also difficulty in lighting and ventilating such a wide barn.

Two-Story Barns. The two-story dairy barn furnishes housing for cattle and the storage of their feed and bedding in one compact building. Such a building requires only one foundation and one roof, but it does require much heavier and stronger construction than does the one-story barn. In the two-story barn, the feed and bedding is conveniently located, which is a great advantage, especially when loose hay and bedding are used. A greater fire hazard exists in this type of barn since many fires start in the hay storage and seldom can be brought under control. Sometimes a reinforced concrete mow floor is built for fire protection, but this type of construction adds to the expense.

One-Story Barn. The one-story barn is a standard stanchion barn with hay and bedding storage in a separate or adjoining building. The one-story barn can be constructed of lighter material and is less costly. When hay and bedding are baled they can easily be moved into the dairy barn for feeding and bedding. If not baled there is more difficulty in handling them than when they are stored overhead in a two-story barn.

Arrangements of Barn. Under average conditions, it requires from 125 to 150 man-hours of labor per cow per year, which is more than for any other animal on the farm. The dairyman is interested in reducing this labor cost and there is no easier way to do this than to have everything in the barn arranged for doing the work in the shortest time possible and with no unnecessary steps. Many things must be considered in such an arrangement, which will be taken up in the following discussion.

Facing Cows In or Out There are advantages and disadvantages to both systems of facing the cows but for most conditions, facing the cow out will reduce the labor A study [*] of the time required to care for a dairy herd showed that 15 per cent of the time was spent in front of the cow 60 per cent behind the cow and 25 per cent in other parts of the barn and in the milk house Since 4 times as much time has to be spent behind the cow as in front of her it is important that this area should be given first preference In cleaning the barn and in milking the cows there is an advantage in having a wide middle alley in the center of the barn in which to do the work There are no side walls behind the cows to keep clean and often a manure spreader is driven through the barn and the manure is handled but once When litter carriers are used only one track through the barn is necessary and there is only one alley to be cleaned each time the cows enter or leave the barn

Those who prefer to face the cows in believe (*a*) that cows make a better showing for visitors when the heads are together (*b*) that the cows are easier to get into their stalls (*c*) that the sun s rays shine in the gutter where it is most needed and (*d*) that the feeding of the cows is made easier because both rows of cows can be fed without back tracking

Size of Barn The width of the barn should not be less than 18 feet for one row of stalls or 36 feet for two rows The length of a barn will depend upon the number of stalls their width and the number and width of cross alleys A barn should not be much longer than 125 to 150 feet Usually when large herds are kept the barns are divided into units each holding about fifty cows Barns much longer than 125 to 150 feet are unhandy to work in as there is too much walking to carry the milk and feed There is also a greater fire hazard in keeping a large number under one roof A cross alley should be provided at each end and in the center when more than 15 stalls are in a row

The height of the ceiling should be 8 to 8¼ feet In cold climates higher ceilings may result in cold barns but in the southern areas the ceiling may be higher to provide more comfort in the summer

[*] *Mich Quart Bul* 30 15 (1947)

Windows. There should be sufficient windows to provide at least 4 square feet of light for each cow Windows should be spaced to supply light to every part of the barn When glass blocks are used, the area should be increased by 50 per cent The windows should be made flush with the inside wall so that there will be no ledges to collect dust and dirt The upper sash should be hinged at the bottom and set in a frame with shields on the side so that by tipping it inward at the top it forms an air intake that directs the incoming air toward the ceiling and prevents a draft on the animals In warm areas it may be the only ventilation used It is known as the "Sheringham System" of ventilation

Stalls. It is quite important to have the proper size of stall Improper size of stalls results in dirty cows and barns, injuries to udders that may lead to mastitis, bruised hocks, and other injuries The size will vary with the size of the cow and the kind of tie that is used Tie stalls require more space than stanchion stalls, but the length and width of stalls should vary so that different sized cows can be accommodated Most stanchions can be adjusted a few inches to accommodate different-sized cows To determine the proper length of a stall for a cow, measure the horizontal distance from the point of the shoulder to the pin bone This distance plus 3 inches gives the correct length from the rear of the manger curb to the edge of the gutter If tie stalls are used, the distance may be increased slightly

The width of the stall should be about 80 per cent of the length Cows should have sufficient room for comfort and should be able to lie down without the danger of their udders being stepped on by the cows next to them The stall should be long enough so that when the cow lies down the entire udder will be on the platform instead of hanging over the edge of the gutter Care must be taken, however, not to have the stalls too long since this leads to dirty cows, especially on the flanks and udders Table LXXXI gives a range in size of stalls for cows of different breeds It must be recognized that cows of the same breed differ greatly in size First calf heifers will need smaller stalls than mature cows

TABLE LXXXI

RANGE IN SIZE OF STALLS FOR COWS OF DIFFERENT BREEDS

Breed	Width		Length	
	Min	Max.	Min	Max
Ayrshire and Guernsey	3 ft 8 in	4 ft 0 in	4 ft 6 in	5 ft 0 in
Holstein and Brown Swiss	4 ft 0 in	4 ft 4 in	4 ft 10 in	5 ft 6 in
Jersey	3 ft. 8 in	3 ft 10 in	4 ft 4 in	4 ft 10 in.

Gutters. The gutters should be 8 inches deep on the stall side and 6 inches deep on the alley side This difference is made because in the first place the cows prefer to step up in entering their stall rather than to step over a deep gutter, and in the second place the cows show up a little better when they stand a little higher The width of the gutter should be 16 inches Most gutters have right angle corners and are level on the bottom Some have been built with round bottoms and others sloped toward the back, in the belief that the liquid will be carried away and hence not soil the tail of the cow The results are not always satisfactory and such gutters are harder to clean

When a mechanical gutter cleaner is to be used a deeper gutter is necessary and the depth is the same on both sides Otherwise the alley way must be ramped up if the gutter crosses the alley at each end of the barn

Mangers Two common kind of feed mangers are in use namely, the low manger and the high back manger In the low manger the feed alley is raised even with the top of the manger so that any feed spilled or thrown out can easily be swept back into the manger

The high back type is built up above the feed alley to various heights It prevents the cow from throwing out as much feed but it is not so easy to get spilled feed back into the manger as with the low type manger The high manger with tie stalls has the advantage of not allowing the cow to push forward so far and is said to be more sanitary since spilled feed when wall

over, will not be swept into the manger. In practice, however, this feed is not usually wasted but is picked up and fed.

Feed Alley. The feed alley needs to be wide enough to provide ample room for feed and silage trucks. There must be room to turn into the cross alleys, and in barns where the cows face out the alleys should encircle the entire barn so that the entire herd can be fed with one trip without back-tracking.

Cross Alleys. Cross alleys at each end of the barn are essential, since they permit the circling of the barn when feeding and will save many steps. When there are more than 30 stalls in the barn, a cross alley should be put in the center also, and usually the milk room is located opposite the center cross alley. Such cross alleys are convenient in saving steps in many ways when caring for the cows.

Litter Alleys. Where cows face out, the litter alley should be wide enough to permit the driving of a manure spreader through for the cleaning of the barn or a truck for hauling bedding into the barn. The alley should be 8 feet from gutter to gutter. When the cows face in, the distance should be at least 5 feet from gutter to wall, as the greater the width the less splash on the walls.

Floors. Concrete is the material most often used for the floors of cow stalls and the floors of the rest of the barn. There are some other materials being used in a limited way but none have been found that will withstand hard usage as does concrete. Some asphalt products mixed with cement and sand have the advantage of being easier on the cows' feet and udder, but do not have good lasting quality. Cork brick, creosoted wood blocks, and rubber mats have been used in cow stalls instead of concrete, but none of them is as durable as concrete. If ample bedding is kept under the cow, the objections to the concrete, namely, that it is hard and cold, may be overcome.

The floor of the dairy barn should slope to central drains, allowing about 1 inch fall for each 10 feet. Such drainage will facilitate the cleaning of the barn with the use of large quantities of water. These drains should be so constructed that they can be closed entirely, to prevent loss of the liquid manure; or they may be provided with a double opening so that liquid manure can be caught and carried to a cistern, and when the

barn is being washed the washings can be run into the regular drain The surface of the floors, especially where cows are to walk, should be properly roughened to prevent danger of the cow slipping

Walls. The most desirable walls for a dairy barn are of concrete or some kind of masonry, although almost any kind of material may be used Some kind of smooth masonry up to the base of the windows is helpful in keeping the barn clean Such can be washed without harmful effects

It has been the custom to paint the walls and ceiling of the dairy stable a white or light gray color, since these colors reflect the light throughout the barn and give it a clean appearance Some successful experimental use has been made of some other colors, such as light green, light blue, and buff The walls and ceiling should be easily cleaned and should look attractive

Ventilation It is important that proper change of air takes place in the barn A well ventilated barn is essential for several reasons (1) Cows need an abundance of fresh air if they are to produce their best and keep healthy (2) Improper ventilation results in a damp, moldy barn, which often leads to unhealthy animals (3) Improper ventilation results in a barn with bad odors, objected to by health authorities (4) Improper ventilation causes too much moisture in the barn, with the result that the wooden parts of the barn will not last for a long period of time, and metal will rust

Amount of Air Needed A 1000 pound cow inhales about 224 pounds of air in 24 hours, which is about twice the amount by weight that she consumes in food and drink It is therefore important that an abundant supply of fresh air be provided at all times

Moisture When the stable is not properly ventilated the air becomes full of moisture A cow will expel from 12 to 18 pounds of moisture per day Stable air contains a varying amount of moisture The warmer the air the more moisture a given volume will hold When the air is loaded with moisture it is said to be saturated The temperature at which the moisture will begin to condense is known as the dew point When cold air entering the stable from the outside is warmed by the heat of the animal, it dries the air in the stable by absorbing the mois-

ture and preventing it from forming on the side of the barn If not enough air gets into the stable to absorb this moisture, it will condense on the walls and ceiling and a damp, unhealthy stable will result By keeping a continuous flow of cold air into and a flow of air out of the stable, this moisture will not form There are two ways to keep the air moving into and out of the barn, the gravity system and the mechanical system

Gravity Ventilation In the gravity system of ventilation, the difference between the inside and outside temperature is the most important factor influencing air movement in the barn An increase of 1 degree in temperature in the stable will increase the volume of 491 cubic feet of air by 1 cubic foot Thus, when the barn air is warmed by the heat of the cows, this increase causes the air to expand against the outside wall, and when there is a flue it tends to force the air through the flue and out of the barn This makes it possible to use a method of ventilation that is automatic One of the first and best of these methods was developed by Professor King at the University of Wisconsin and is known as the King system of ventilation

King System of Ventilation A 1000 pound cow inhales about 224 pounds of air in 24 hours, which amounts to 3542 cubic feet per hour, or 59 cubic feet per minute Air has been found to move through a flue 1 square foot in size at the rate of 295 cubic feet per minute For the King system, the size of outlet needed to pass this air out of the barn should be computed For example, to ventilate a barn holding 50 cows, the formula would be 59 cubic feet air $\times$ 50 cows = 2950 cubic feet of air per minute to be removed Then, 2950/295 = 10 square feet of outtake

If two outtakes are used they must contain 5 square feet each, which would be supplied with two outlets 2 feet by 2½ feet in size, one near each end of the barn

The intakes are smaller in size but more numerous for better distribution of air movement and the total square surface of the intakes should be slightly in excess of that of the outtake Usually, about 1 square foot (10 inches $\times$ 14 inches) should be provided for every five or six cows For a barn holding fifty cows, about four or five inlets, evenly distributed, should be placed on each side of the barn These should enter near the ceiling

but the outside opening of these inlets should be at least 3 feet below the inside opening in order to prevent the warm air from flowing out The outtake of the King system extends to or near to the floor since theoretically it would there draw off the heavier, impure air and less of the warm air In practice how ever the outtake flues are taken off from the ceiling mainly be cause it is inconvenient for the herdsman to have these large

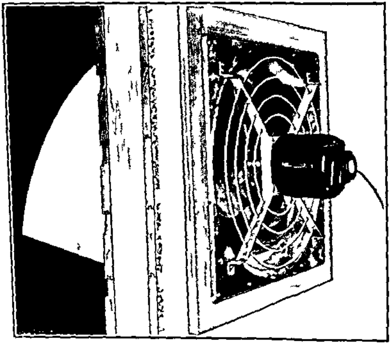

Fig 49 Electric wall fan for ventilating a dairy barn (*James Mfg Co*)

flues extending to the floor The ventilation flues should be tight and if metal they should be insulated to prevent conden sation The outlets and intakes may be provided with dampers so that the rate of flow of air may be regulated This system works only when the barn is closed and tight It will not work if windows and doors are open

Mechanical Ventilation On farms where electric current is available the electric fan is being used to force the air out of the barn The fans can be installed at less cost than the gravity system but there is the continual cost of electricity It is usu ally recommended that the same kind and number of intakes

be provided as with the gravity system For a barn of 50 cows, it is recommended that two 14- or 18 inch fans be installed, one of which may operate continuously when needed, and the other should be thermostatically controlled so that it will operate only when needed This system gives more positive ventilation than does the gravity system

Window Ventilation The Sheringham System of ventilation has already been discussed The windows are hinged at the bottom and set in frames with shields on the side so that the inflowing air is directed toward the ceiling thus avoiding drafts on the animals Such a system may be all that is necessary in the warmer climates where the barn can be kept open most of the time However, for the colder areas, this system is not recommended, since the warmer and not the coldest air is removed, the barn is inclined to be drafty, and the open windows interfere with the operation of the gravity or forced air systems of ventilation

Storage Capacity. The average cow will consume 1 to 2 tons of hay yearly A ton of loose hay requires from 400 to 500 cubic feet of space A little more space is needed per ton for straw, and ½ to 1 ton is used yearly for bedding an animal A ton of sawdust occupies 144 cubic feet of space, and 1½ tons are needed per cow annually Baled shavings require 160 cubic feet per ton, and ½ to ¾ ton is needed per cow yearly A cow eats from 3 to 5 tons of silage yearly, and a cubic foot of silage weighs about 40 pounds A storage capacity of approximately 100 cubic feet is necessary for an entire year's supply of the grain feed for a cow

Feed Room and Silos The feed room and silos should be located on the side of the barn either at the center or near the end, depending on the length of the barn The feed room usually connects the barn and the silo There should be ample space in the feed room to store several days supply of feed and for the storage of the feed cart Often, the feed is stored on the second floor and the feed flows from the storage bin directly into the feed truck The excess feed is stored and mixed on the second floor or in a separate building The silo should empty on the same level as the barn floor The silage is most easily handled in a silage truck

Milk House The milk house should be located on the side of the barn opposite the feed room, silos, and manure storage to avoid odors Usually, to save steps, the milk house is located near the center of the side of the barn It should not open directly into the barn, but may be connected with a breezeway, at least one side of which may be enclosed It should be located on the side of the barn next to the service area to permit access of the milk truck.

A standard milk house has three rooms, one for cooling and storage of the milk, one for washing the utensils, and the third for the boiler and machinery for operating milkers, refrigeration units, etc Where electric heaters are used for sterilization and heating of water, this third room may be quite small or entirely eliminated

THE LOOSE HOUSING DAIRY BARN OR OPEN-SHED BARN

The loose housing of dairy cattle has been used for many years There has been a revival of interest in this system, as it lends itself to the saving of labor, lower stabling costs, and more comfort for the cows It is used in conjunction with a small milking building of some type, through which the cows are relayed to be milked There are several systems of loose housing The early system was where the cows were turned into a common area, where they were fed their hay and silage, and given access to a watering trough and a bedded area

The plan now becoming popular is to separate the feeding and bedding area The hay and bedding may be kept on the ground floor The hay may be fed by allowing the cows free access to it in the barn or it may be fed outside in hay racks and the silage fed in silage bunks This area may be partially under cover or entirely in the open and should be paved Various self feeding arrangements have been developed for feeding both the hay and the silage The feeding area is not bedded and must be cleaned regularly The bedded area must have bedding added freely but needs to be cleaned only once or twice a year This area will require a head room of 9 to 10

feet to allow for a deep manure pack and the operation of a tractor loader

The feeding area should be provided with from 2 to 2½ feet of manger space per cow The watering trough will be located in this area A large part of the manure will be dropped here, which will keep the bedding area cleaner and will save bedding The entrance to the milking room may be from the feeding place, preventing so much movement back and forward over the bedded section It should have a concrete floor so that it can be easily cleaned When the feeding and bedding areas are separate, about 60 to 70 square feet per cow for the bedded area are required

Amount of Bedding The loose housing system requires from 2 to 3 times as much bedding as a stanchion barn The necessity for this large amount of bedding is one of the greatest drawbacks to this system of housing With more grassland farming and less grain grown, there is often not enough straw to do a good job of bedding That is one reason for dividing the feeding and bedding area This area must be kept well bedded

Comfort and Health of Animals The loose stable system does not require that the barn be entirely enclosed In fact, it is often better to have it open to the east or south The cows should be kept dry and out of drafts but no provisions need be made for ventilation when the barn is open When well fed they will produce just as well in loose housing with an open side, even in extremely cold weather, as they will in enclosed barns They may consume a little more roughage during cold weather The manure pack maintains a warm temperature, somewhere between 70° and 90°F a few inches below the surface, and this pack is a warm, soft bed for the cows and is a protection for the udders Cows will not suffer from knee or hock injuries, will not become stiff and lame, and will have fewer tramped on udders and teats when in loose barns than when kept in stanchions Of course, it is more essential to dehorn all animals when kept in a loose stable, and even when dehorned there will still be some boss cows that will give trouble It is easier to detect cows in heat when they run loose

Effect on Quality of Milk It is possible to produce high quality milk from cows kept in loose housing and milked in a

separate room These cows are milked in a small area used only for milking, where there are no barny or cowy odors since the cows are kept in this room for only a short time There is no dust from the hay nor odor from the silage If the bedded area is kept properly bedded the cows will stay clean

Effect on Production of Cow A study at Wisconsin * covering a 5 year period showed little difference in production between the cows kept under loose housing conditions and those kept in a stanchion barn A United States Department of Agriculture † study showed that cows in loose housing produced more milk than those kept in stanchions There seems to be little difference in production as influenced by the method of housing

The Pole Barn Loose housing barns have been made with a minimum of expense by the use of poles that have been treated with creosote products under high pressure These poles are set in the ground and serve as both the foundation and support and will last for many years

The Milking Area The type of milking area used in connection with the loose housing varies greatly, but they can be put into three classes, namely, (*a*) small milking barn, (*b*) the milking parlor, and (*c*) the Rotolactor, but there are many modifications of these

Small Milking Barn The small milking barn is usually a conventional type stanchion barn with from four to twenty stalls In practice, it is used only for holding the cows at milking time Here they are fed their grain and sometimes their silage The milk house is often built as a part of this barn The size of the herd is limited only by the number of changes to be made for the milking The barn should be kept clean and meet the requirements of the health officials

The Milking Parlor. The milking parlor differs from the small milking barn in that the milking parlor is so designed that the cows are milked in a continuous operation, rather than milking one group, then replacing them with another group of cows It may contain from two to eight milking stalls, depending

* *Agr Eng*, 27 11 (1947)
† *U.S D.A Circ* 763 (1946)

somewhat on the size of the herd The stalls may be abreast or in tandem, and are usually elevated so that the milker is in a pit on a lower level than the cows The milker can do the milking without stooping There are many designs of such parlors It is small in area and is easy to keep clean Sometimes it is provided with a glass front, through which spectators can watch the process of milking the cows The milking parlor has the advantage that the milking is done in a clean and compact space where the milk is carried only a short distance.

Pipe-Line Milkers. In pipe line milking, the milk goes directly from the milking machine through a sanitary pipe line to the cooler or holding tank and often to the bottles where it is bottled During the entire process it does not come in contact with human hands This type of installation is common in milking parlors and works quite satisfactorily

The Rotolactor. A more expensive system called the Rotolactor was first operated at the Walker-Gordon Laboratories in New Jersey In this system the cows are placed on a circular rotating platform where their udders are first washed and dried and then milked by machine When a cow makes the circuit she is completely milked and is removed and another takes her place The platform holds 50 animals at a time and is used to milk 1600 cows 3 times per day There is a smaller Rotolactor in operation in Massachusetts, which holds only 10 cows and milks 400 per day These are too expensive for most farms, since the same advantage can be obtained by less expensive equipment

Advantages and Disadvantages of the Loose Housing System of Housing as Compared to the Stanchion Barn

The advantages and disadvantages of the loose housing or open shed system of handling dairy cattle as summarized from a circular put out by the Michigan Experiment Station * are as follows

1 It costs less to construct, since costly items such as stanchions, expensive concrete work, and form building, insulation

* *Mich Exp Sta Special Bul.* 363 (1950)

and ventilation system, and individual drinking cups are omitted

2 Labor can be used more efficiently, since cows travel to their feed and to the milking parlor

3 The cows have more comfort, which promotes better health and vitality. Animals have a keener appetite for roughage, because of lower temperature and more activity

4. Less leg, teat, and udder injuries result

5 There is more and better quality manure

6 It permits greater flexibility, making it possible to change the number of cows or even to change to other livestock enterprises without remodeling

7. Hay can be kept in front of the cows at all times Self-feeders can be filled 2 or 3 times per week, thus reducing the time and labor requirements

The disadvantages are given as follows

1 The temperature of the work place may be too low for comfortable working conditions in the cold weather Of course, the milking parlor can be heated at low cost, but the remainder of the barn may be cold

2. More bedding is required It requires about twice as much bedding as when the cows are kept in stanchions Where bedding is scarce this is a real disadvantage

3 Boss cows often annoy and sometimes injure the more timid individuals If the feeding area is large this may be partially overcome, but sometimes animals may fail to get enough to eat and drink and may go down in milk flow

4 It is necessary to have stanchions in the maternity stall for the artificial breeding of cows and for administering medicine, etc.

5 The routine of milking in a milking parlor is not as quickly learned by hired help

HOUSING OTHER DAIRY CATTLE

The housing of the milking herd is much more important than that for other dairy cattle However, provision must be made for housing cows at calving time and also calves, yearlings, and bulls There is also a need for isolating animals at times and for a hospital stall

Maternity Stalls. One maternity stall should be provided for every eight or ten cows in the herd. The cows in the maternity stall should be maintained under the same condition of temperature and protection as the milking herd. The size of the maternity stall varies with the size of the cow. Smaller cows will need about 100 square feet, and larger cows about 120 square feet of floor space. A deep stall (8 x 14 feet) is preferred to a more nearly square stall (10 x 12 feet), since they are easier to keep clean.

Calf Stalls. Calves can stand considerable cold even from birth, if they are protected from drafts and dampness. Some dairymen prefer to house calves in a tight stable, whereas others keep them in a barn open to the south. It is desirable to have calves in individual pens during the time they receive milk or fluid milk replacements to prevent them from sucking each other. A rectangular pen with 24 to 30 square feet of floor space is desirable. After they are weaned from milk feeding they may be run in groups. Where more than one calf is placed in a pen, a stanchion or tie to use during feeding will insure that each calf has the opportunity to get its feed.

One building may be used as a combination maternity barn and calf barn. This makes for convenience of caring for and looking after the cows at calving time and caring for the young calves. In cold weather the cow will help to warm up the barn.

Barns for Yearlings. Yearlings may be housed in open barns, but should be protected from drafts, rain, snow, and winds. They do not need to be housed in a closed barn.

It is often advisable to have the heifer barn located some distance from the other cattle. This will help to reduce the amount of mud around the barn and it distributes the fire hazard. It will also give more area for the heifers to run free around the barn than if a larger number are kept at one place.

Bull Barns. Bulls need to be protected from the mud and rain but should not be housed in a tight barn. The bull barn should be arranged so that the bull can be fed and watered without entering his pen or stall. Also, a safety breeding chute should be built into the pen or lot to eliminate danger at time of breeding. The bull stall should not be in the dairy barn but should be accessible.

Isolation and Hospital Stalls. When a cow is injured, sick, or in heat she should be isolated from the remainder of the herd The maternity stall is satisfactory for most cases However, there are cases of sickness that are contagious These animals should be isolated to protect the remainder of the herd Some injuries require special stall equipment for treatment A special stall built away from the other barns is helpful in handling these cases

REFERENCES FOR FURTHER STUDY

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35

Dairy Barn and Milk-House Equipment

The equipment of dairy barns is so far from being standardized that no attempt will be made to enumerate all the different devices that are on the market or to discuss the advantages and disadvantages of different kinds of equipment. Some of the more common devices and their principles and uses will be discussed. Because of the constant changes in particular makes of equipment, trade terms will not be used in this discussion.

TYPES OF STALLS

The three main types of dairy-barn stalls are the stanchion stall; the tie stall; and the comfort stall.

The Stanchion Stall. The stanchion stall is the standard dairy-cow stall. It is equipped with a stanchion for fastening the cow in place. Usually there is a stall partition in the form of a curved pipe between the stalls to keep the cows in place and to protect their udders and teats from being stepped on by other cows.

The stanchion should be made of metal but may have a wooden liner that fits next to the cow's neck. The stanchions should be so constructed and arranged as to allow the cows the greatest possible freedom. There should be several links of chain at the top and bottom of the stanchions and sufficient room on each side of it to permit the animal to move its head from side to side. Comfort is just as important as proper alignment.

The stall should be of a size that would best fit the cow (see Chapter 34). This is important to provide comfort for the cows and to line them up so that the majority of the droppings and

FIG 50 Tie stalls (*Howe*)

FIG. 51 Comfort stalls. The cows move forward to lie down on the bedding held in place by the crossbar When they stand up with head raised, the pipes in front of the stall cause them to step back to the rear portion of the stall platform (*W Va Univ*)

urine will go into the gutter. It is not possible to have every cow fit her stall properly. To compensate for this, many stanchions have adjustments so they can be set forward if the cow is too large for the stall, or backward if the cow is too small. The adjustable stanchion makes it possible for the dairyman to align the cows even with the gutter, thus keeping the stalls and the cows cleaner.

The cow can be fastened easily and quickly with stanchions, and is held more closely in place than with other types of ties. However, she is held more rigid and therefore the stanchion is less comfortable than other types of fasteners. Large cows often have difficulty in getting up in stanchion stalls. Smaller cows seem to get along better in these stalls than larger cows. However, even small cows sometimes cannot adapt themselves to the stanchion stall.

The Tie Stall. The tie stall should be a few inches longer and wider than the stanchion stall. It is designed to give more comfort to the cow. In addition to the larger size, the chain tie gives the cow more freedom. Instead of the stanchion there are two arches, one on each side of the cow's neck. The cow is fastened by means of rings fitted loosely on the arch pipes and connected to a chain which snaps to the neck strap on the cow. The correct space between the arches is 10 to 12 inches. This prevents the cow from moving too far forward in the stall.

In this type of stall the arches and all other stall parts are kept lower than the cow's height. This is an advantage when showing the cattle as there are no obstructions over the cows. Purebred breeders often prefer this type of stall for that reason. The cow has more freedom in the tie stall than in the stanchion. Large cows and those with large udders get along in them better because of the freedom. A tie chain in a small stall is undesirable.

The Comfort Stall. The comfort stall is designed in various ways from the original Hoard comfort stall. These stalls are larger and have a series of horizontal pipes over the manger to prevent the cow from standing too far forward. A single chain clamped to one of these pipes is snapped to the cow's neck strap as a tie.

An adjustable crossbar is placed across the rear of the stall to hold the bedding in place The piping in front of the stall is located at a height that allows the cow to go forward when she is eating or lying down Consequently, when she lies down she lies entirely in front of the crossbar and on the bedding When she stands up, the pipes cause her to step backward, which allows the droppings to go behind the crossbar and not on the bedding area Cows in these stalls are more comfortable and remain cleaner than in either of the other types

PARTITIONS Partitions between the stalls are essential in the tie stalls and the comfort stalls and are desirable in stanchion stalls A bent pipe is sufficient for the stall division for the tie stall and the stanchion stall Additional dividers are necessary for the comfort stall A concrete curb between the stalls is needed for the comfort stalls and is occasionally used with the tie stalls

COMPARISON OF TYPES OF STALLS The comparison of tie stalls and comfort stalls at the West Virginia Experiment Station * showed that cows in comfort stalls produced more milk, sustained fewer injuries, remained cleaner, and spent more time lying down The cows in the comfort stalls spent an average of 10 2 hours per day lying down, whereas those in the tie chain stalls spent an average of 8 8 hours lying down

Another study on types of stalls was made at the Virginia Experiment Station,† using the stanchion, the tie stall, and the comfort stall The results are reported in Table LXXXII

More time was required to clean the manure and soiled bedding from the comfort stalls than from the other stalls The slight difference in time required to clean and brush the cows was only slightly in favor of the cows in the comfort stalls

The stanchions required only about one half as much time for fastening and unfastening the cows as did the comfort stalls The amount of time, however, was very small for either type of stall The cows in the comfort stalls remained the cleanest, whereas those in the tie stalls were the dirtiest The comfort stalls are slightly more expensive, since they are larger They are often used instead of box stalls for cows on official test.

* *J Dairy Sci*, 34 149 (1951)

† Thesis, J W Howe, Va Poly Inst., 1951

TABLE LXXXII

Comparison of Three Types of Stalls

	Stanchion Stalls	Tie Stalls	Comfort Stalls
Time required to clean and brush cows (min. per day)	1.66	1.67	1.56
Time required to clean stall platform (min. per day)	0.74	0.82	1.47
Time required to fasten cows (min. per cow)	0.096	0.119	0.167
Time required to attach and detach milker hose to and from stall cock (sec. per cow)	8.63	8.68	8.87
Amount of manure on cows (ave. score)	1.47	2.05	0.78

Manger Divisions. Metal dividers in the manger will allow each cow to get her own feed. When all the cows are fed at the same time, dividers are not essential but are desirable. With manger divisions, more time is required to clean the mangers.

Watering Devices. The system of turning cows out to drink once or twice a day is followed quite extensively. Some dairymen run water in a concrete manger in front of the cows. Cows, however, will produce a little more milk if they are given access to water at all times; also, there is less opportunity for diseases to be transmitted from one to another when they have individual drinking cups. For these reasons, many dairies have individual watering cups that give the cows access to fresh water at all times. There are two general systems of supplying water to watering cups. One is the gravity system, in which water is kept at a certain level in the cups by means of a large tank, provided with a float, at one end of the building; the other is the pressure system, in which the water is forced to the cups and let in by a valve, which the cows soon learn to operate. The latter is to be preferred where the water system permits. The objection to the gravity system is that when the water in the tank becomes low the water from the drinking cups flows back, so that if any of the cows have an infectious disease it may spread throughout the entire herd in this way. The same objection was found in the old-type pressure systems, but the modern drinking cup of this type has the valve at which the

water enters the bowl above the normal level of water in the cup so that it is impossible for the water to flow back.

Care should be taken to keep the cups clean Many cups now on the market give satisfaction

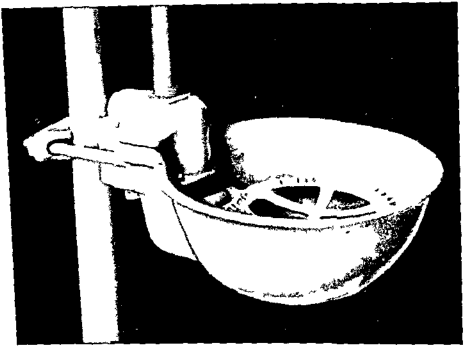

FIG 52 A watering cup arranged so that the cow can let the water in as she drinks.

Calf Pens. Calf pens should be dry and well ventilated, but care should be taken that they are free from drafts They should be provided with stanchions or ties, so that the calves may be tied to prevent their sucking one another after they have finished drinking their milk Dividers in the mangers, between the stanchions, will prevent the calves from sucking In summer, calves are often allowed to run in an open lot This should also be provided with stanchions where the calves may be tied when being fed This makes it much more convenient to feed and at the same time insures every calf its allotted ration

Pens may be made of metal panels or wood When wood is used, the panels or partitions should be made so that they can

be removed for cleaning. Removable mangers are desirable for small calves. They can be taken out, cleaned, and disinfected.

Fig. 53. A silage cart on rubber tires makes silage feeding easier (*W. Va. Univ.*).

FEEDING EQUIPMENT

Feed Carts. Several tons of feed are handled each year for each cow in the herd. The use of feed carts reduces the labor of moving the feed by requiring fewer trips to be made in feeding the herd. Suitable carts may be homemade or purchased from a commercial manufacturer. Where heavy loads are to be moved, the cart should be on rubber wheels. Rubber tires are quiet, save wear on the alley ways, and make the load easier to move.

Divisions in the grain cart will give space for two or more feed mixtures, such as one for the milking herd and one for dry

cows A vertical bar can be attached to the feed cart to support a feed scale for accurate feeding of each cow If the feed scale is not used, a scoop holding a known amount or one with the scale on the handle can be used A feed chart listing the amount to be fed each cow can be fastened on the cart

The silage cart needs to be large enough to reduce the number of trips necessary to feed the herd The silo chute should be constructed so that the cart will fit directly under it The silage can be thrown into the cart from the silo and save an extra handling of the silage Some feed carts and litter carriers are mounted on an overhead track These are largely being replaced by carts on wheels The tracks are expensive and with heavy loads give more trouble than a truck on wheels

Hay Carts Baled hay may be easily moved with or without a cart or truck Loose hay offers more of a problem if it is to be moved a great distance A truck with a large bed may be used to advantage

Silo Unloaders Mechanical silo unloaders have been developed One type is placed in the top of the silo and is lowered by pulleys as the silage is used It has revolving arms that rake the silage to the center It is then blown into the silo chute Another type is an endless chain type that is built into the bottom of the silo

Bale Elevators Motor driven bale elevators and conveyors are used for storing baled hay and straw They will also handle loose grain and bags of feed The elevator and conveyor can often be relocated to remove feed during the winter for feeding This gives double use of the equipment without additional expense

Feed Grinders and Mixers When a considerable portion of the feed is grown on the farm, a feed grinder is usually a good investment It may be operated by motor or tractor If the quantity of feed to mix is large, a mixer will be a good investment It is not as necessary as the grinder The mechanical mixer will do a more efficient job of mixing than is usually done by hand mixing

A considerable amount of metal objects often finds its way into feeds Some are sharp pointed and dangerous when taken into the stomach of the cow A magnet may be located on a

feed chute leading to the grinder or the mixer, for removing at least some of the metal pieces that may be in the feed. For small quantities of feed, two or three strong horseshoe magnets are quite effective. For larger operations, an electromagnet can be installed in connection with the grinder or mixer and is more effective.

MILKING EQUIPMENT

Milking Machines. Practically all commercial herds and many small herds are now milked with machines. The reason for the great increase in the use of the milking machine is that (*a*) much labor is saved; (*b*) a high-quality milk can be produced; (*c*) a high-production level can be maintained and (*d*) the milking task is made less objectionable. The greatest advantage of the milking machine is that the job of milking is made easier and the drudgery is taken out of milking so that less trouble is experienced in securing labor. A person may be a good machine milker but not a good hand milker. Many farm families can do their own milking with the use of a machine, thus saving in the hiring of extra labor.

Other Milking Equipment. The job of milking will be better organized and easier to perform if all the milking equipment is handled together. A rubber-tired platform truck will serve well as a milking equipment cart. All the equipment may be assembled on the cart and taken to the milking barn. With all the necessary materials and equipment concentrated in this manner, the procedure will be more orderly and easier.

The equipment needed will include the milker units, pails for washing udders, pails for dipping teat cups, a strip cup, and pails for carrying the milk. A container for holding towels for washing the udder can also be provided. A frame built on the cart will hold the milk sheet for recording milk weights. Milk scales may be attached to an arm on the cart.

MILK HOUSE EQUIPMENT

The equipment for the milk house should be suitable for handling the grade of milk that is being sold and adequate for the amount of milk that is produced

Washroom Equipment A two compartment wash vat is desirable and required on some markets A storage for milk cans and all dairy utensils may be a can and utensil rack or an enclosed cabinet The latter is often the sterilizing cabinet Solution racks for milking machine teat cups can be located conveniently in the washroom A cabinet for storing supplies and materials is convenient and makes it possible to keep them in a more orderly condition

Boilers and Heaters Hot water may be supplied by a steam boiler a steam generator or a hot water heater With the increased availability and use of electricity an electric water heater is often used Where steam sterilization is required an electric steam sterilizing cabinet is suitable There is on the market an electric steam boiler which is designed to be used in place of the conventional steam boiler It is not as yet in general use Preliminary observations and tests indicate that it is satisfactory

Amount of Hot Water A study was made at the Virginia Experiment Station * of the amounts of hot water used in the barn and milk house for various operations in producing high quality milk The following amounts of hot water were used at each milking for the different operations in a fifteen cow dairy and in a thirty cow dairy

	For 15 Cows gallons	For 30 Cows gallons
For rinsing equipment	3	4
For washing udders	6	12
For dipping teat cups	4	8
For washing and rinsing utensils	20	30
For washing hands	3	6
	—	—
Total for one milking	36	60

Milk Cans and Utensils The number of milk cans required depends on whether two sets are needed or whether the hauler

* Va Exp Sta Rept (1950)

returns the cans the same day in time for use for the afternoon milking There must be a sufficient number to handle the maximum daily production of the year.

Where hand milking or hand stripping is practiced, covered milk pails are needed Where milking machines are used, additional milker pails with covers are most desirable for carrying the milk from the barn to the milk house This eliminates the pouring of the milk in the barn into other pails for carrying Milk strainers equipped with single use strainer pads are the only kind recommended There should be two strainers for every three milker units operated to allow ample time for filtering A strip cup is needed by each operator

Cooling Facilities. The original method of cooling milk was to set cans of milk in spring or well water Later, milk-cooling tanks were built to hold the cans of milk These tanks were supplied with water from a spring or well These methods are still in use for much of the milk produced for manufacturing purposes and for sour cream

Milk Coolers. High quality milk that is to be used for bottled milk and is to be delivered with a low bacteria count needs to be cooled more quickly, which requires a cooling medium Ice has been used, and to some extent is still used, as the cooling agent. With greater availability of electricity, mechanical refrigerators are universally used where Grade A milk is produced Many different types of refrigeration systems are in use

Aerator For quickest cooling, the milk is allowed to run slowly over a tubular cooler or aerator The cooling medium is usually the regular water supply for the top section of the cooler with water from a wet storage refrigerator pumped through the bottom section of the cooler For larger operations, a direct-expansion cooler is often used For storage after cooling, a wet storage or a walk-in cold air storage room may be used

Wet Storage The wet storage box can be used to do the entire cooling job The cans of warm milk are set directly into the wet storage.

Cold-Wall Milk Tank The cold-wall milk tank is the latest development in milk cooling The equipment is more expensive than other types It is an efficient method of cooling and when

MILK HOUSE EQUIPMENT

The equipment for the milk house should be suitable for handling the grade of milk that is being sold and adequate for the amount of milk that is produced

Washroom Equipment. A two compartment wash vat is desirable and required on some markets A storage for milk cans and all dairy utensils may be a can and utensil rack or an enclosed cabinet The latter is often the sterilizing cabinet Solution racks for milking machine teat cups can be located conveniently in the washroom A cabinet for storing supplies and materials is convenient and makes it possible to keep them in a more orderly condition

Boilers and Heaters Hot water may be supplied by a steam boiler, a steam generator, or a hot water heater With the increased availability and use of electricity, an electric water heater is often used Where steam sterilization is required, an electric steam sterilizing cabinet is suitable There is on the market an electric steam boiler which is designed to be used in place of the conventional steam boiler It is not as yet in general use Preliminary observations and tests indicate that it is satisfactory

Amount of Hot Water A study was made at the Virginia Experiment Station [*] of the amounts of hot water used in the barn and milk house for various operations in producing high quality milk The following amounts of hot water were used at each milking for the different operations in a fifteen cow dairy and in a thirty cow dairy

	For 15 Cows, gallons	For 30 Cows, gallons
For rinsing equipment	3	4
For washing udders	6	12
For dipping teat cups	4	8
For washing and rinsing utensils	20	30
For washing hands	3	6
Total for one milking	36	60

Milk Cans and Utensils The number of milk cans required depends on whether two sets are needed or whether the hauler

[*] *Va Exp Sta Rept* (1950)

returns the cans the same day in time for use for the afternoon milking There must be a sufficient number to handle the maximum daily production of the year

Where hand milking or hand stripping is practiced, covered milk pails are needed Where milking machines are used, additional milker pails with covers are most desirable for carrying the milk from the barn to the milk house This eliminates the pouring of the milk in the barn into other pails for carrying Milk strainers equipped with single use strainer pads are the only kind recommended There should be two strainers for every three milker units operated to allow ample time for filtering A strip cup is needed by each operator

Cooling Facilities The original method of cooling milk was to set cans of milk in spring or well water Later, milk cooling tanks were built to hold the cans of milk These tanks were supplied with water from a spring or well These methods are still in use for much of the milk produced for manufacturing purposes and for sour cream

Milk Coolers High quality milk that is to be used for bottled milk and is to be delivered with a low bacteria count needs to be cooled more quickly, which requires a cooling medium Ice has been used, and to some extent is still used, as the cooling agent With greater availability of electricity, mechanical refrigerators are universally used where Grade A milk is produced Many different types of refrigeration systems are in use

AERATOR For quickest cooling, the milk is allowed to run slowly over a tubular cooler or aerator The cooling medium is usually the regular water supply for the top section of the cooler with water from a wet storage refrigerator pumped through the bottom section of the cooler For larger operations, a direct expansion cooler is often used For storage after cooling, a wet storage or a walk in cold air storage room may be used

WET STORAGE The wet storage box can be used to do the entire cooling job The cans of warm milk are set directly into the wet storage

COLD-WALL MILK TANK The cold wall milk tank is the latest development in milk cooling The equipment is more expensive than other types It is an efficient method of cooling and when

used in connection with tank truck delivery, no milk cans are required.

CLEANING EQUIPMENT

Litter Carriers. In some barns, the cows are turned out each day and the manure is disposed of by driving through and loading it directly on the spreader. If the herd is large enough to supply a load of manure each day, this is a saving of labor; otherwise, more time is required to do this than to store the manure.

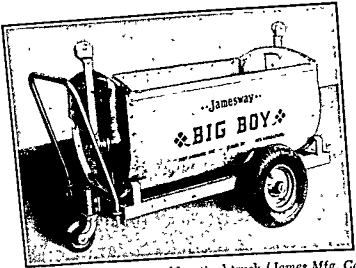

Fig. 54. Litter carrier on rubber-tired truck (*James Mfg. Co.*).

In a small herd, a wheelbarrow or small truck may be us
A smooth walk should be made leading to the manure pit, wh
should be located at least 50 feet from the barn.

The most common system in dairies of any size is the lit
carrier. A large quantity can be moved more easily in this v
than on a wheelbarrow. The manure may be dumped dire
into a spreader or may be emptied into a manure pit, wher
may be stored until a convenient time for spreading.

Mechanical Gutter Cleaner. Mechanical gutter cleaners
remove the manure from the gutter and load it on a spreade
truck are coming into use. This is one of the greatest la

Electric Clippers The clipping of certain areas of the cow is necessary for clean milk production Electric clippers make this job rather easy It is more convenient if electric outlets are provided on each support post so that they will be sufficiently close for the clipper cord to reach

Electric Cow Trainers An electric fence control can be con nected with a crossarm supported over the back of the cow This is called a cow trainer When the cow humps her back to defecate or urinate the crossarm will shock her and causes her to step back and drop in the gutter These trainers have been quite effective in keeping the cows clean Most cows soon learn to step back before dropping and the stall platform remains cleaner Longer stalls can be used with the trainers Some cows do not readily adjust themselves to the trainers and their pro duction is affected adversely

Steam Jenny A high pressure steam jenny is a piece of equip ment that operates by an oil burner It is connected with a pressure water system with a hose Detergent is added to it and the solution is discharged through a steam hose at a high temperature The use of this equipment is an easy method of cleaning stalls walls ceilings and any other surfaces The high temperature and detergent solution will also disinfect the area cleaned

MISCELLANEOUS EQUIPMENT

Holding and Loading Chutes Every dairy farmer must han dle cattle several times each year for such purposes as bleeding for Brucellosis testing for tuberculosis spraying treating for warbles and probably dehorning A holding chute makes this handling much easier The chute may be built in connection with stocks for holding the animals Often the milking herd can be held in the stanchion barn for a part of these operations The chutes will still be needed for handling young stock and others not stanchioned Loading chutes are convenient when moving cattle

Breeding Rack The breeding rack is used for two purposes (1) for the breeding of small cows or heifers by a large bull or

of large cows by a small bull and (2) for the breeding of animals that do not readily stand

Occasionally, a bull will serve to better advantage when a rack is used. The breeding rack should probably be used more

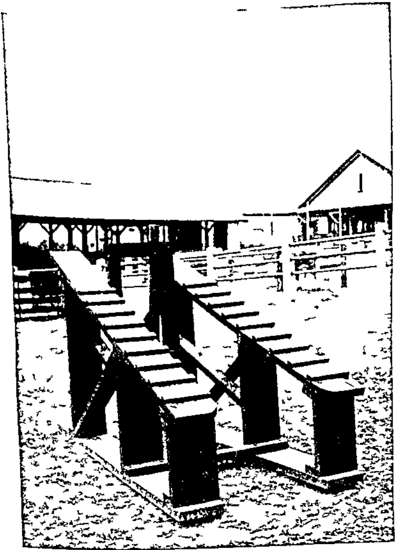

Fig 56 Breeding Rack Dimensions, floor planks 9 feet long, front post 4 feet, and rear posts 1½ feet One and one half feet between floor planks in front and 2 feet in rear

than it is, but because of the inconvenience of adjusting it for each animal and because of the trouble of bringing both animals to it, most herdsmen do not usually use it until it is absolutely necessary The stanchion of the rack should be adjusted so that a small animal can be held back and a large animal allowed to go forward It is well to have the sloping part on which the

of large cows by a small bull and (2) for the breeding of animals that do not readily stand.

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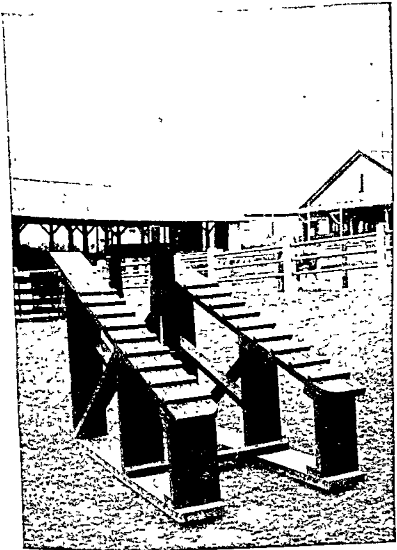

FIG. 56. Breeding Rack. Dimensions, floor planks 9 feet long, front post 4 feet, and rear posts 1½ feet. One and one-half feet between floor planks in front and 2 feet in rear.

than it is, but because of the inconvenience of adjusting it for each animal and because of the trouble of bringing both animals to it, most herdsmen do not usually use it until it is absolutely necessary. The stanchion of the rack should be adjusted so that a small animal can be held back and a large animal allowed to go forward. It is well to have the sloping part on which the

bull's front feet rest provided with cross strips, as well as a strip along the outer side to keep the bull's feet from sliding off. The dimensions and method of construction are shown in Fig. 56.

Stocks. Stocks are strongly made crates in which animals can be held successfully during the trimming of hoofs or dehorning,

FIG. 57. Stocks. Dimensions, total length 9 feet, height 6 feet. Width inside 2 feet 4 inches, and 2 feet 8 inches from stanchion to floor ring.

or while other operations are being performed, when it is necessary to have the animal under full control. Stocks are especially useful for the handling of bulls. They should be constructed of good material and well bolted together. They should be made adjustable so that they can be used to hold animals of different sizes. This can be done by having several slots for

the timber inserted at the back to hold the animal in place, an the same may be done for the stanchion It is sometimes diffi cult to get animals into a stock This is especially true of bull The difficulty can be overcome by proceeding slowly and, necessary, tying the obstinate bull for a little while at the en trance to the stock Figure 57 shows the construction and d mensions of a satisfactory cattle stock

Tool Rack. A tool rack is convenient for storing tools an equipment used in the dairy barn Forks, scoops, brooms, curry combs, brushes, etc, should be stored in an accessible place an in an orderly manner The rack should be conveniently locatec but some dairymen build the rack on rollers so that it can b moved where most needed and even outside the barn

REFERENCES FOR FURTHER STUDY

1 Porterfield, Hyatt, Brown, and Longhouse A Comparison of Comfo and Tie Stalls, *J Dairy Sci*, 34 149 (1951)

2 Dairy Cattle Housing *Wisc Exp Sta Bul* 470 (1950)

3 Catalogues of barn equipment companies

4. R M Carter, Labor Saving Through Farm Job Analysis—Dairy Bar Chores *Ver Exp Sta Bul* 503 (1943)

5 Catalogues of dairy equipment supply companies

Appendix

Laboratory Exercises

In the teaching of dairy cattle feeding and management, the practicum should form an important part of the work. Usually, only one laboratory is allowed per week, but sometimes there are two. A sufficient number of exercises are outlined in the following pages to occupy two laboratory periods for a full semester. In institutions providing only one laboratory period each week, certain exercises may be omitted without in any way interfering with the continuity of the work. Such exercises are marked with a (*). Others may be added if necessary.

In some exercises it may not be possible, with large classes, to schedule all the students to meet at the same time. This applies to such exercises as milking, calf feeding, etc. The class may then be divided into groups and assigned to work at various times outside of regularly scheduled periods. In other exercises, such as figuring rations, it is believed desirable that all work be done by the students, independently, in a classroom, under the supervision of an instructor.

Exercise 1. Identification of Feeds

As many feeds as can be obtained should be placed in convenient containers so that the students can observe and study them. During the laboratory period the names of the different feeds are placed on the containers and the student is required to make a study of the characteristic appearance, odor, weight, bulk, and any other property that the feed may possess. Defects of any particular feeds or characteristics that distinguish grades or qualities of a particular feed should be discussed. Ready-mixed feeds that are common in the state may also be used. After the students have had time thoroughly to familiarize them-

selves with the feeds, certain of the feeds should be prepared with labels removed and a test given on identification of feeds.

REFERENCE Chapter 6.

Exercise 2. Cost of Feeds

A list of all the common feeds and roughages in common use in the state and the current price per ton should be given to each student The student should obtain the pounds of digestible protein and total nutrients of each feed from the tables, and from these calculate the cost of 100 pounds of feed, of 1 pound of digestible protein, and 1 pound of digestible nutrients This should be kept for calculation of feed costs in the following exercises.

REFERENCE Chapter 10, Table A (Appendix)

Exercise 3. Requirements for Maintenance, Milk Production, Growth, and Pregnancy

The requirement for maintenance of cows and heifers under various conditions, as indicated in the problems, should be calculated

Problems 1 A 1000 pound cow is producing 40 pounds of 4 per cent milk per day How much digestible protein, total digestible nutrients, calcium, phosphorus, carotene, and salt should she be fed daily in order to meet her requirements?

2 A 1200 pound cow is dry and within a week or two of freshening How much digestible protein total digestible nutrients, calcium, phosphorus, carotene and salt should she be fed? If she needs iodine, what would be the recommendations?

3 A heifer weighing 400 pounds should be fed how much digestible protein, total digestible nutrients, calcium, phosphorus, carotene, vitamin D, salt, magnesium, cobalt iron, and copper?

4 How much alfalfa hay would you need to feed the cow in Problem 1 to meet her calcium needs? her phosphorus needs? How much timothy for calcium needs? phosphorus needs? How much wheat bran for calcium needs? phosphorus needs?

5 How much alfalfa would you need to feed to meet carotene needs for the heifer in Problem 3? How much timothy? How much corn meal? How much cottonseed meal? How much wheat bran?

REFERENCE. Chapters 8, 10, and 11, Table B (Appendix).

Exercise 4. Rations Are to Be Calculated Using the Morrison Standard for Digestible Protein and Total Digestible Nutrients of Feeds

Problems. 1. Calculate a ration for a 1000-pound cow giving 32 pounds of 5 per cent milk, when the following feeds are available.

Timothy hay	Wheat bran
Corn silage	Soybean meal
Corn meal	Gluten feed

Calculate also the cost of the ration, the feed cost of 100 pounds of milk, and the feed cost per pound of butterfat

2 Calculate a ration for a 1300-pound cow giving 45 pounds of 4 per cent milk, with the following feeds available.

Corn silage	Corn-and-cob meal
Alfalfa hay	Gluten feed
Beet pulp	Hominy
Wheat bran	Ground oats
Cottonseed meal	Soybean-oil meal

Determine the cheapest ration, using only such feeds as are necessary for proper balancing Figure also the cost of 1 pound of digestible protein and 1 pound of digestible nutrients.

REFERENCE. Chapters 10 and 11; Tables *A* and *B* (Appendix).

Exercise 5(*). Rations Are to Be Calculated Using the Morrison Standard for Digestible Protein and Net Energy Values of Feeds

Problems 1. Calculate a ration for an 850-pound cow giving 20 pounds of 5 2 per cent milk, with the following feeds available.

Mixed hay	Ground oats
Corn stover	Wheat bran
Corn meal	Linseed meal

Determine the returns for $1 00 expended for feed when milk sells at $4 00 per hundred.

2 Calculate a good ration, using any feed on list, for a Guernsey cow weighing 1100 pounds and producing 32 pounds of 4 7 per cent milk.

Consider the characteristics of a good ration. Other things being equal, the cheapest ration is the best. Discuss reasons for using various feeds.

REFERENCE. Chapters 9, 10, 11; Tables *A* and *B* (Appendix).

Exercise 6 Calculating Rations for the Herd

Usually it is not practical to calculate a ration for every cow in the herd and it is therefore necessary to calculate a ration for the entire herd The student should familiarize himself with the method

Balance Ration According to Average Cow in the Herd

Problems 1 Calculate a grain ration for a herd of Jersey cows averaging 30 pounds of 5 per cent milk. The roughage available is corn silage and alfalfa hay Corn meal and ground oats are available the other concentrates must be purchased

2 A man has a herd of twelve Ayrshire cows averaging 35 pounds of milk per day He has the following feeds available

Timothy hay	Corn and-cob meal
Corn silage	Ground oats

Determine the cheapest grain ration to feed using all the above feeds and making any additional purchases necessary Figure the cost of the grain mixture per 100 pounds Make enough of the mixture to last two weeks Discuss amount of roughage and grain to feed and reason for purchasing such feeds as are purchased

Reference Chapter 10

Exercise 7(*) Calculating Rations for the Herd

This method is somewhat simpler even than the one shown in Exercise 6 Since there is seldom a deficiency in total nutrients when the herd has all the roughage that they will eat a roughly balanced ration can be formulated by balancing the protein of the grain mixture to suit the kind of roughage available

Balancing for Protein

Problems 1 A dairyman has a herd of twenty Holstein cows averaging 38 pounds of milk per day He has on hand timothy hay corn silage, corn and-cob meal and ground oats Calculate a good grain mixture for this herd, using the feeds available and any others necessary Give reason for the different ingredients and figure costs Calculate amount of all feed that will be required in such a herd for a 6-month feeding period

2 A man has a herd of twenty Jersey cows with an average production of 26 pounds of milk The following feeds are available

Oat straw	Linseed meal
Corn and cob meal	Cottonseed meal
Hominy	Dried beet pulp
Alfalfa hay	Wheat bran
Gluten feed	

Calculate a good grain mixture, using any of the above feeds How much feed will be necessary for feeding this herd from September 15 to May 15? Calculate the storage room necessary to store this amount of feed Give method of feeding, amount fed, and cost of ration

REFERENCE Chapter 10.

Exercise 8(*). Calculating a Feed Formula

Rations figured as done by commercial feed companies is a great help in understanding the value of feeds as they are designated on the feed tag. In this, the ration should contain the specific amount of protein called for, at least 3 5 per cent fat, 70 0 per cent total digestible nutrients, and not over 10 per cent crude fiber

Problems 1 Calculate a 16 per cent crude protein ration, showing the amount of digestible protein, crude protein, crude fat, crude fiber, total digestible nutrients, and the cost of the ration Using any of the feeds necessary in order to produce a good ration, add 1 per cent salt and 2 per cent bone meal

2 Calculate a 20 per cent protein ration, as above

3 Calculate a 32 per cent protein ration, as above

REFERENCE Chapter 10

Exercise 9. Using the Pearson's Square, Calculate the Following Problems

1 If you have a ton of 32 per cent mixture and you wish to mix it with ground oats or corn to make a 20 per cent mixture, how much oats would be required? How much corn?

2 If you wish to mix 1 ton of 16 per cent dairy feed, and you have on hand corn meal and ground oats and 43 per cent soybean oil meal, and you wish to use equal parts of corn and oats, how much soybean-oil meal would be used?

3. If you have 1200 pounds of corn and 800 pounds of oats, which you wish to mix with a 32 per cent grain mixture, how much of the 32 per cent would you need to make a 16 per cent mixture?

4 You have corn-and cob meal and ground oats to feed with alfalfa hay and corn silage You wish to feed 2 parts of corn to one of oats and to mix this with a 32 per cent protein mixture You have a herd of ten Jersey cows which are producing an average of 33 pounds of milk per day How much of the 32 per cent supplement would you have to purchase for a month's supply if you feed your herd 1 pound of feed to each 3 pounds of milk produced? How much corn and cob meal and oats would you feed?

5 How much corn and oats would you need to mix with a 32 per cent mixture to have a 20 per cent protein ration, and how much of each would be necessary to feed a herd of 20 Holstein cows averaging 40 pounds of 3 5 per cent milk for a 6 month period?

REFERENCE Chapter 10

Exercise 10(*). Economy of Heavy Feeding

Problem Assume a 1200 pound Holstein cow with a capacity for producing 50 pounds of 3 5 per cent milk Will it be economy to feed her enough for only 35 pounds of milk per day? for 25 pounds? Calculate a ration for such a cow by the Morrison Standard for 25, 35, and 50 pounds daily, and include the cost of the ration, of 100 pounds of milk, and of 1 pound of butterfat

REFERENCE Chapters 7 and 10

Exercise 11(*). Law of Diminishing Returns

Does it pay to get the greatest production possible from a cow, or is there a point above which it is not profitable to go?

Problem Using the feeds and prices as figured in Exercise 2, calculate rations for a Jersey cow weighing 900 pounds and with milk testing 5 per cent, under the conditions listed at top of page 577, considering pasture worth $5 00 per month

Find the feed cost per pound of fat, the total cost of 1 pound of fat, the percentage digestible nutrients in roughages, and the percentage digestible nutrients in concentrates Explain the results by means of graphs

REFERENCE. Chapter 12

Corn (grain), 70 bushels per acre
Oats (grain), 50 bushels per acre

Calculate the feed needed for this herd and plan a cropping system for next year Grow all the roughage needed and only as much corn and oats as there are acres for Figure how many acres of each should be grown and how much grain should be purchased Figure size of silo, and space for storing hay and bedding and grain

REFERENCE Chapter 11

Exercise 14 Mixing Rations

The students should be given one exercise in the proper mixing of a ration The feeds should be laid out on the floor in the required amounts and thoroughly mixed If a mixer is available, experience in its operation should be given

REFERENCE Chapter 10

Exercises 15 and 16 Feeding Practice

Two laboratory periods are devoted to actual feeding practice One cow or more is assigned to two students, who are required to figure a good ration for this cow, using the feeds available The students are required to weigh out the feed necessary and to have the cow fed according to their directions The cow should be weighed at frequent intervals At the end of a 10 day feeding period a full report should be submitted

REFERENCE Chapters 6, 7, 10, and 11

Exercise 17(*). Calf Feeding

One laboratory period should be devoted to calf feeding A schedule should be arranged in which the students are required to prepare the feeds and to carry out the complete work of feeding calves This is done under the supervision of the instructor Practice should be given in the removal of extra teats, dehorning, tattooing, and eartagging

REFERENCE Chapters 16 and 18

Exercise 18(*). Milking by Hand

The student should demonstrate his ability to milk a cow quickly, completely, and in a satisfactory manner. Those who have had experience in milking before taking the course can demonstrate in one milking whether or not they can do the work satisfactorily. Students without such experience require several milking periods in order to be given credit for this exercise. The work should be done under the supervision of the instructor.

REFERENCE. Chapter 17.

Exercise 19(*). The Use of a Milking Machine

The student is assigned an exercise in the operation of the milking machine. He will be required to assemble the machine, do the milking, and then thoroughly wash and sterilize the machine.

REFERENCE. Chapters 17 and 32.

Exercise 20(*). Valuation of Dairy Animals

The students should have had a course in dairy-cattle judging before this laboratory exercise. For this, several animals of each class are used, and the student is required to give his estimate of the money value of each of the animals, which should include cows, bulls, heifers, and calves. This exercise should train the student in the purchase of animals and enable him to use his previous training in the determining of age and to make practical application of his ability to judge production. If the records and the pedigrees of the animals are known, this information should be given. At the end of the period the inventory value of the animal is told to the student.

REFERENCE. Chapters 29 and 30.

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REFERENCE Chapters 29 and 30

Exercise 21. Marking and Sketching Cattle

The students should be familiarized with the different methods of marking cattle and with the method of tattooing and putting tags in the ear

They should also be furnished with special blanks for registration of animals of the different breeds, and each should be required to make drawings and fill out in full application for registration

REFERENCE Chapter 16

Exercise 22(*). Herd Development

As many animals as the herd has of one family should be compared with a family that has multiplied but little, thus emphasizing the value of vitality and reproduction The inheritance of certain characteristics can well be brought out The daughters of one bull may also be studied, especially in regard to type and production

REFERENCE Chapters 22 and 23

Exercise 23(*) Handling Cow and Calf at Calving Time

Assign a student a springing cow to watch and, if possible, to be near at the time of the birth of the calf He should (1) check breeding dates and determine when the calf is due, (2) feel for calf in right flank of cow and watch for evidence of approaching calving, (3) move the cow into a box stall and watch when calf is born, to give aid if necessary, (4) see that afterbirth is passed and remove it from the stall, (5) disinfect the navel of the calf as soon as possible and paint with iodine, (6) see that the calf starts to nurse and gets some colostrum, and, except for heifers, do not allow the cow to be completely milked for the first few days, (7) see that the cow is given warm water and a warm bran mash, (8) thoroughly disinfect the stall after the calf has been removed

REFERENCE. Chapters 16 and 18

Exercise 24(*). Handling Bulls

Study the bull pen and lot and note safety features. Study the safety breeding chute and take measurements. Make a drawing of the chute, putting in measurements. If possible, put a ring in the nose of the bull. If the bull has a ring in his nose, examine it for size and see that the screw is holding. Lead the bull with a safety staff. Make a drawing of a safety bull pen that would be an improvement over the one that has been visited.

Reference. Chapter 20.

Exercise 25. Fitting for Show

Students are assigned animals to be fitted for show. A careful inspection of the animals is made by the instructor before the fitting begins. Some students are given cows, others bulls, and others heifers or calves. A sufficient supply of the equipment necessary for fitting for show should be on hand, and the students should be shown how to use it. It is often desirable at the end of the last period to hold a show so that lessons in fitting may be pointed out. Also, the methods of handling cattle in the show ring can be demonstrated.

Reference. Chapter 31.

Exercises 26 and 27. Barn Plans

Two exercises in drawing a barn plan are given. Each student is required to hand in drawings according to the following suggestions and specifications. The work can be done either in the classroom or elsewhere. The former is preferable if equipment is available. During the first exercise, measurements on size of stable should be made.

Requirements for Dairy Plans

Drawing must be made on regulation-size, white drawing paper (18 x 24 inches). It must be made to a scale of not more than 1 inch equals 6 feet. A margin of ¾ inch must be

left on the drawing paper The drawing must be inked in with regulation black drawing ink All dimensions of the barn must be shown A space at the lower right-hand corner of the drawing must be saved for the name, date, scale, and grade The size of the space should be 4 by 2½ inches The elevation and floor plan should be shown

REFERENCE Chapter 34

Exercise 28(*). Barn Equipment

A list of all the equipment in the dairy barn should be made This should include kind of ties, stalls, feeding arrangement, method of ventilation, and all other equipment Drawings should be made of such equipment as ventilators, special stalls, etc.

REFERENCE Chapter 35

Exercises 29 to 35 Dairy-Farm Problem

The object of this dairy farm problem is to bring together in a fairly comprehensive way some of the factors that must be considered in laying out a dairy farm business All points having a direct and definite bearing upon the dairy problem should be considered The farm may be the home farm of the student, some farm with which he is acquainted, now used as a dairy farm, or one that he may be interested in converting into a dairy farm, or it may be purely imaginary The last, however, is not desirable The barn plans and equipment in Exercises 26 and 27 may also be made with the same farm in view

1 The Layout

A The farmstead

(1) Layout of farm, size, etc To scale, notebook size paper
(2) Make a list of fields and total expected *crop yields*
(3) Location of the house, barn etc , to scale
(4) Estimated value of the dairy barn and equipment

2. Give Area, Yield (in Pounds), Use, and Sales of All Crops Grown on the Farm Use a form like the following (following

tables are only samples to show the kind of work and forms to be used):

Crops	Area	Yield per Acre	Total Yield, pounds	Sales, pounds	Used, pounds	Value of Crop

3. **The Livestock.** Show the numbers and values of animals that you would start with at the beginning of the year, the estimated sales, purchases, and deaths, and the numbers and values at the end of the year, by a table like the following. Indicate the date of sales and purchases that greatly affect the numbers of animals.

COWS, HEIFERS, BULLS, AND CALVES

Number, Beginning of Year			Sales			Purchases			Died	Number End of Year		
No.	Value	Total	No.	Value	Total	No.	Value	Total		No	Value	Total

4. **Feed Used.** Decide upon the rations to be fed the different animals during the year. Base the rations on good feeding practices and current feed prices. Fill out a table like the following, to show the feed, pasture, and bedding requirements. Include each kind of feed and each kind of roughage separately. If the animals are fed different rations during different parts of the year, give the ration for each period on a separate line.

Number of Animals	Feeds Fed during Year								
	Days	Per Day	Total	Per Day	Total	Per Day	Total	Per Day	Total
___ Cows ___ Heifers 1-2 yr ___ Heifers under 1 yr ___ Bulls									
Total for 12 mo. Home raised feed used Bought feed used									

5. Cost of Production. In consideration of feeding practice and management on the farm, what would be the probable cost of keeping the dairy herd?

Cost		
Feeds	Grain	$______
	Hay	______
	Other dry forage	______
	Silage	______
	Other succulence	______
	Pasture	______
Labor	Man ___ hr ___ per hr.	______
	Truck ___ hr ___ per hr	______
	Interest on investment	______
	Depreciation on dairy cows	______
	Bedding	______
	Use of building, 4 per cent value	______
	Depreciation	______
	Bull service	______
	Other costs ___	______
	___	______
	Total	______

6. Receipts. The receipts from cows should include milk and milk products sold or used on the farm, manure produced, and

value of calves at birth, also, hides, etc. Use a form like the following.

Milk sold ____ lb. Price per 100 lbs.	$______
Milk used on farm ____ lb.	______
Manure ____ tons. Price per ton	______
Calves ____	______
Other receipts ____	______
Butter ____ lb.	______
Cream ____ gal.	______
Total	______

7. Costs. The products of the dairy herd consists of milk, manure, calves, and miscellaneous receipts In order to find the cost of producing milk, we must assume that manure, calves, and miscellaneous receipts are valued at cost Subtract the value of manure, calves, and miscellaneous receipts from the total cost to find the cost of producing milk. Use the following form.

Total cost from 5	$______
Value of manure, calves, etc , from 6	______
Cost of producing milk	______
Cost per cwt	______
Cost per qt.	______
Cost per lb. butterfat	______

8. Dairy Management Methods. (Thesis about 1000–1500 Words)

- (A) *Dairy cows*
  - (*a*) Kind and production
  - (*b*) Management, breeding, etc.
  - (*c*) Methods of breeding, stabling, etc.
- (B) *Bulls*
  - (*a*) Scheme for stabling, feeding, handling, etc.
- (C) *Heifers*
  - (*a*) Methods of feeding, stabling, etc
  - (*b*) Breeding and management.
- (D) *Calves*
  - (*a*) Scheme for stabling, feeding, handling, etc
- (E) Methods of disposal of dairy animals and products.

9. Balance Sheet. Make a balance sheet showing net returns of whole farm, considering other side lines, expenses, and increase or decrease in total capital.

Reference Chapters 11, 30, and 33.

Appendix Tables

TABLE A

Average Nutrient Composition of Some Common Feeds *

Feed	Dry Matter per cent	Total Protein, per cent	Digestible Protein, per cent	Total Digestible Nutrients per cent	Net Energy Therms per 100 Pounds	Calcium per cent	Phosphorus per cent	Carotene mg. per pound
Grains and Other Seeds								
Barley common	89.4	12.7	10.0	77.7	70.5	0.06	0.37	0.19
Beans, field or navy	90.0	22.9	20.2	78.7		0.15	0.57	
Buckwheat, common	88.0	10.3	7.4	62.2	60.8	0.09	0.31	
Corn, dent, No. 1	87.0	8.8	6.8	82.0	82.0	0.02	0.28	
Corn, dent, No. 2	85.0	8.6	6.6	80.1	80.1	0.02	0.27	2.2
Cottonseed whole	92.7	23.1	17.1	90.8	76.6	0.14	0.70	
Cowpea, whole	89.0	23.4	19.2	76.0	76.0	0.11	0.46	0.11
Emmer grains	91.1	12.1	9.7	72.2	67.7		0.33	
Feterita grains	89.4	12.2	9.5	79.8	77.9	0.02	0.33	
Milo grains	89.4	11.3	8.8	80.1	77.9	0.03	0.30	
Oats, not Pacific Coast	90.2	12.0	9.4	70.1	72.1	0.09	0.34	0.05
Pea seed, field	90.7	23.4	20.1	77.9	77.9	0.17	0.51	
Rice grain	88.8	7.9	6.0	70.2	80.1	0.08	0.32	
Rye grain	89.5	12.6	10.0	76.1	70.5	0.10	0.33	0.04
Shallu, grain	89.8	13.4	10.5	80.7				
Sorghum seed (Sweet)	89.2	9.5	5.8	77.5		0.02	0.28	
Soybean seed	90.0	37.9	33.7	87.6	87.6	0.25	0.59	0.38
Wheat, average	89.5	13.2	11.1	80.0	80.0	0.04	0.39	0.04
Mill By-Products								
Apple pomace dried	89.4	4.5	1.7	64.0		0.10	0.09	
Apple pomace wet	21.1	1.3	0.5	16.0		0.02	0.02	
Beet pulp, dried	90.1	9.2	4.3	67.8	76.1	0.67	0.08	
Beet pulp, wet	11.6	1.5	0.8	8.8		0.09	0.01	
Blood flour soluble	92.2	84.7	81.3	83.9		0.68	0.50	
Blood meal	91.8	84.5	60.0	61.3		0.33	0.25	
Bone meal, raw	93.6	26.0	17.9	17.9		23.05	10.22	
Bone meal, steamed	96.3	7.1				31.4	13.00	
Brewers grains, dried, 25% protein and over	92.9	27.6	22.1	67.1	67.2	0.29	0.48	
Brewers grains, dried, below 25% protein	92.3	23.4	16.8	61.8	67.2			

* Taken by special permission of the Morrison Publishing Company Ithaca, New York, from *Feeds and Feeding* 21st edition, by F. B. Morrison.

TABLE A (*Continued*)

Average Nutrient Composition of Some Common Feeds

Feed	Dry Matter per cent	Total Protein per cent	Digestible Protein per cent	Total Digestible Nutrients, per cent	Net Energy Therms per 100 Pounds	Calcium, per cent	Phosphorus per cent	Carotene mg. per pound
Brewers' grains wet	23 7	5 7	4 2	16 1	16 1	0 07	0 12	
Buckwheat middlings	88 7	29 7	25 8	75 7			1 02	
Citrus pulp dried	90 1	5 9	2 5	74 4	75 0	2 07	0 15	0 10
Citrus pulp wet	18 3	1 2	0 5	15 1				
Cocoanut oil meal hydr or exp process	93 2	21 3	18 1	77 7	77 7	0 21	0 64	
Corn-and-cob meal	86 1	7 3	5 3	73 2	71 4		0 22	
Corn bran	90 6	9 7	5 5	69 4		0 03	0 27	
Corn feed meal	88 6	9 8	7 5	83 1	83 1	0 03	0 34	
Corn-germ meal	93 0	19 8	14 8	76 1			0 58	
Corn gluten feed	90 9	25 5	21 9	76 0	72 2	0 48	0 82	6 1
Corn-gluten meal	91 4	43 1	36 6	80 2	80 2	0 13	0 38	10 0
Corn-oil meal (o p)	91 7	22 3	16 1	77 1	70 2	0 06	0 56	0 2
Cottonseed meal 43% protein	92 7	43 9	36 4	75 8	76 9	0 23	1 12	
Cottonseed meal 41% protein	92 8	41 5	32 8	70 6	70 6	0 20	1 22	0 09
Cottonseed meal below 41% protein	92 4	38 2	30 2	68 9	67 5	0 23	1 29	
Distillers dried corn grains without solubles	92 9	28 3	20 7	82 4	82 4	0 11	0 47	
Distillers dried corn grains with solubles	93 1	28 8	21 0	80 9	80 9	0 16	0 74	
Distillers dried corn grains solvent extrac	93 7	33 4	24 4	71 2				
Distillers dried rye grains	93 9	18 5	11 1	60 8	58 5	0 13	0 43	
Distillers solubles, dried, corn	93 0	26 7	19 5	77 1		0 30	1 41	
Fish meal all analyses	92 9	63 9	56 2	72 8	72 8	4 14	2 67	
Hominy feed, 5% fat or more	90 4	11 2	8 0	84 5	84 5	0 22	0 71	4 10
Hominy feed low in fat	89 7	10 6	7 5	81 4				
Linseed meal, all analyses o p	91 0	35 4	30 8	77 2	78 3	0 39	0 87	0 14
Malt sprouts	92 6	26 8	20 6	70 9	61 7			
Molasses, beet	80 5	8 4	4 4	60 8		0 08	0 02	
Molasses, cane or blackstrap	74 0	2 9	0 0	54 0	68 1	0 74	0 08	
Oatmeal, or rolled oats without hulls	90 8	16 0	14 4	91 4		0 07	0 46	
Oat mill feed	92 4	5 6	3 7	37 6	40 0	0 13	0 16	
Palmo middlings	94 1	16 1	13 4	85 5				
Pea feed or meal	90 0	17 7	14 5	77 9	70 9			
Peanut-oil meal, o p. all analyses	93 0	43 5	39 6	82 4	83 6	0 16	0 54	0 08
Rye middlings	90 2	16 6	12 6	73 0			0 44	
Screenings, grain, good grade	90 0	15 8	11 4	67 8	57 6			
Soybean-oil meal expeller or hydraulic process, all analyses	90 9	44 3	37 2	78 4	78 4	0 29	0 66	0 09
Soybean-oil meal, solvent process	90 6	46 1	42 4	78 5	78 4	0 30	0 66	
Wheat bran, all analyses	90 1	16 9	13 7	67 2	67 2	0 14	1 29	0 08
Wheat red dog	89 0	18 2	16 0	85 6	83 6	0 07	0 51	
Wheat screenings, good grade	90 4	13 9	10 0	63 7		0 44	0 39	
Wheat middlings, standard, all analyses	89 6	18 1	15 0	77 2	77 2	0 09	0 93	
Wheat, brown shorts	88 7	16 9	14 4	74 3	66 9			

TABLE A (*Continued*)

Average Nutrient Composition of Some Common Feeds

Feed	Dry Matter per cent	Total Protein per cent	Digestible Protein, per cent	Total Digestible Nutrients, per cent	Net Energy Therms per 100 Pounds	Calcium per cent	Phosphorus, per cent	Carotene, mg. per pound
Wheat, white shorts	89.7	18.1	14.2	85.9	85.9			
Yeast, brewers, dried	93.8	49.3	42.4	70.5	59.9	0.13	1.56	
Yeast, irradiated, dried	93.9	48.7	41.9	70.2		1.48	1.28	
Milk and By-Products								
Buttermilk	9.4	3.5	3.3	9.1	10.4	0.14	0.08	
Buttermilk, condensed	29.7	10.9	9.8	26.5		0.44	0.26	
Buttermilk, dried	92.4	32.4	29.2	84.0	88.8	1.36	0.82	
Milk, cow's	12.8	3.5	3.3	16.3	19.6	0.12	0.09	0.44
Skim milk, centrifugal	9.5	3.6	3.4	8.7	10.4	0.13	0.10	
Skim milk, dried	94.2	34.7	31.2	80.7	88.8	1.30	1.03	
Whey, from cheese	6.9	0.9	0.8	6.5	6.5	0.05	0.04	
Whey, dried	93.5	12.2	11.0	78.3	78.3	0.86	0.72	
Legume Hays								
Alfalfa hay, all analyses	90.5	14.8	10.5	50.3	41.0	1.47	0.24	11.4
Alfalfa hay, leafy	90.5	15.8	11.7	51.5	42.2	1.50	0.24	19.4
Alfalfa hay, stemmy	90.5	12.1	8.1	46.2	34.3	1.10	0.18	3.2
Alfalfa leaf meal, good	92.3	21.2	16.1	56.7	47.1	1.69	0.25	81.5
Alfalfa meal, good	92.7	16.1	11.8	53.6	44.2	1.32	0.19	43.4
Alfalfa and timothy	89.8	11.1	6.6	49.1		0.81	0.21	
Clover hay, alsike, all analyses	88.9	12.1	8.1	53.2	43.6	1.15	0.23	
Clover hay, crimson	89.5	14.2	9.8	48.9	39.1	1.23	0.24	
Clover hay, ladino	88.0	19.4	14.2	54.9		1.32	0.29	
Clover hay, mammoth red	88.0	11.7	6.8	52.0			0.24	
Clover hay, red, all analyses	88.1	11.8	7.1	52.2	42.8	1.35	0.19	8.6
Clover hay, sweet, first year	91.8	16.5	11.9	50.3	41.0	1.37	0.26	
Clover hay, sweet, second year	90.7	13.5	9.4	47.3	35.5	1.25	0.23	
Clover and timothy hay	88.1	8.6	4.8	51.2	41.0	0.68	0.20	
Cowpea hay, all analyses	90.4	18.6	12.3	51.4	40.8	1.37	0.29	
Kudzu hay	89.0	15.9	10.7	49.2		2.78	0.21	17.8
Lespedeza hay, annual, all analyses	89.2	12.7	6.4	47.5	39.0	0.98	0.18	22.4
Lespedeza hay, perennial	89.0	13.2	4.4	41.4		0.92	0.22	15.9
Pea hay, field	89.3	14.9	10.6	55.1	41.3	1.22	0.25	
Pea and oats hay	89.1	12.1	8.6	52.9	39.7	0.72	0.22	
Peanut hay, without nuts, good	90.7	10.1	6.6	51.9	38.9	1.12	0.13	8.0
Peanut hay, with nuts	92.0	13.4	10.2	71.6		1.13	0.15	
Soybean hay, all analyses, good	88.0	14.4	9.8	49.0	34.8	0.94	0.24	13.6
Vetch hay, common	89.0	13.3	10.1	55.3		1.18	0.32	
Vetch hay, hairy	88.0	19.3	15.2	57.1		1.13	0.32	
Nonlegume Hays								
Barley hay	90.8	7.3	4.0	51.9	40.5	0.26	0.23	
Bluegrass hay, Kentucky, all analyses	89.4	8.2	4.8	54.8		0.46	0.32	
Brome-grass hay	88.1	9.9	5.0	48.9	38.6	0.20	0.28	
Millet hay, foxtail	87.6	8.2	4.9	50.0	37.5	0.29	0.16	
Oat hay	88.1	8.2	4.9	47.3	38.8	0.21	0.19	
Oat-grass hay, tall	88.7	7.5	3.4	47.4			0.14	

TABLE A (*Continued*)

Average Nutrient Composition of Some Common Feeds

Feed	Dry Matter per cent	Total Protein per cent	Digestible Protein per cent	Total Digestible Nutrients per cent	Net Energy Therms per 100 Pounds	Calcium per cent	Phosphorus per cent	Carotene mg. per pound
Orchard-grass hay early cut	88 6	7 7	3 9	47 8	36 8	0 19	0 17	
Prairie hay western good quality	90 7	5 7	2 1	49 6	37 2	0 36	0 18	9 3
Redtop hay	91 0	7 2	3 2	48 7	37 5	0 38	0 23	
Rye hay	91 3	6 7	2 8	44 7			0 18	
Sudan grass hay in bloom	89 2	8 4	4 7	51 8	38 6			
Timothy hay all analyses	*89 0*	*6 5*	*2 9*	*48 9*	*38 6*	*0 23*	*0 20*	*5 3*
Wheat hay	90 4	6 1	3 3	46 7	35 0	0 14	0 18	
Straws and Fodder								
Barley straw	90 0	3 7	0 7	42 2	22 4	0 32	0 11	
Buckwheat straw	88 6	4 3	1 2	37 5		1 24	0 04	
Corn fodder well eared very dry	91 1	7 8	3 8	58 8	39 4	0 24	0 16	1.8
Corn stover very dry	90 6	5 9	2 1	51 9	27 0	0 29	0 05	
Cowpea straw	91 5	6 8	2 0	38 3				
Flax straw	92 8	7 2	5 8	38 1		0 48	0 07	
Kafir fodder very dry	90 0	8 7	4 5	53 6	39 2	0 35	0 18	
Kafir stover very dry	90 0	5 5	1 9	51 3	27 7	0 54	0 09	
Oat straw	89 7	4 1	0 7	44 7	23 3	0 19	0 10	
Rice straw	92 5	3 9	0 6	41 5		0 19	0 07	
Rye straw	92 8	3 5	0 0	42 2	9 0	0 26	0 09	
Sorghum fodder sweet, dry	88 8	6 2	3 3	52 4	35 1	0 34	0 12	1 1
Wheat straw	92 5	3 9	0 3	40 6	10 0	0 21	0 07	
Silages								
Alfalfa wilted	36 0	6 0	4 1	21 3	18 1	0 51	0 12	14 3
Alfalfa molasses, not wilted	26 8	4 1	2 7	15 4	13 2	0 41	0 08	14 5
Alfalfa, molasses wilted	36 6	6 0	4 0	21 4	18 4	0 56	0 11	
Apple pomace	20 9	1 6	0 6	15 5		0 02	0 02	
Clover red	30 9	4 0	2 6	18 3	15 6	0 50	0 07	
Clover red molasses	33 7	4 4	2 8	19 9				
Clover sweet	28 0	4 5	3 4	15 7				
Corn dent well matured all analyses	27 4	2 2	1 2	18 1	15 2	0 10	0 06	6 4
Corn dent, stover silage	23 0	1 5	0 6	13 1	9 1	0 08	0 01	
Corn and soybeans, well matured, 30% soybeans	28 3	3 2	2 0	19 7	19 7	0 20	0 08	
Kafir	29 7	2 1	1 1	16 9	12 7	0 07	0 05	
Oats, molasses added	32 0	2 7	1 4	16 9		0 08	0 07	17 7
Pea, field	27 9	3 8	3 0	18 2		0 38	0 08	
Potato, mixed hay	33 7	3 8	2 2	21 6				
Rye with molasses	23 7	2 4	1 0	11 4				
Sorghum, sweet	25 3	1 6	0 8	15 2	12 2	0 08	0 04	2 7
Soybeans, wilted	33 2	5 6	3 9	19 1	16 2	0 45	0 12	14 6
Sudan grass	26 3	2 3	1 6	14 7				
Sunflower	22 6	2 1	1 0	12 2	10 4	0 39	0 04	
Timothy wilted	40 8	4 4	2 2	23 5	20 0	0 23	0 12	14 1
Timothy wilted molasses	42 5	4 1	2 1	25 5		0 22	0 16	
Vetch	30 1	3 5	2 0	18 9				
Vetch and oats	26 4	2 2	1 5	15 4	13 1			

TABLE A (*Continued*)

Average Nutrient Composition of Some Common Feeds

Feed	Dry Matter per cent	Total Protein, per cent	Digestible Protein, per cent	Total Digestible Nutrients, per cent	Net Energy Therms per 100 Pounds	Calcium per cent	Phosphorus, per cent	Carotene, mg. per pound
Roots and Tubers								
Beets, common	13.0	1.6	1.2	10.1	10.1	0.03	0.04	
Beets, sugar	16.4	1.6	1.2	13.7	13.7	0.04	0.04	
Carrots	11.9	1.2	0.9	10.3	10.3	0.05	0.04	27.2
Mangels	9.2	1.3	0.9	7.0	7.0	0.01	0.03	
Potatoes	21.2	2.2	1.3	17.9	17.9	0.01	0.05	
Pumpkins, field	10.4	1.7	1.3	9.0			0.04	
Rutabagas	11.1	1.3	1.0	9.5	9.5	0.05	0.03	
Sweet Potatoes	31.8	1.6	0.2	26.1	26.2	0.03	0.04	
Turnips	9.3	1.3	0.9	7.8	7.8	0.06	0.02	
Green Forage								
Alfalfa, all analyses	25.3	4.5	3.4	14.7	12.8	0.35	0.07	28.3
Alfalfa and timothy half and half	21.7	4.3	3.4	14.1		0.30	0.07	
Barley fodder	22.2	3.2	2.3	14.2	12.1	0.07	0.08	20.9
Bluegrass Kentucky pasture	30.2	5.5	3.9	19.2	16.7	0.16	0.13	36.0
Brome grass, smooth, good pasture	25.0	5.2	3.7	15.5	13.5	0.12	0.08	31.6
Clover crimson	17.4	3.0	2.3	11.3		0.24	0.05	
Clover Ladino pasture	16.3	4.4	3.7	11.4		0.20	0.07	25.2
Clover mammoth red	25.1	4.0	2.8	16.4				
Clover red, all analyses	25.0	4.0	2.8	16.8	14.6	0.38	0.06	20.9
Clover sweet, in bloom	29.2	5.5	4.2	19.0		0.37	0.07	
Clover and mixed grasses pasture well grazed	20.0	4.5	3.4	13.9	12.1	0.23	0.07	
Corn fodder dent, all analyses	24.0	2.0	1.2	16.3	14.2	0.06	0.05	
Corn stover green	22.7	1.3	0.5	13.0	11.6	0.07	0.01	
Kafir fodder all analyses	23.6	2.4	1.2	14.4	12.2	0.09	0.05	
Kudzu	30.6	5.5	4.2	19.9		0.96	0.07	
Lespedeza, annual, pasture	25.0	4.1	2.0	12.7	11.0	0.28	0.07	
Millet, foxtail	29.9	2.9	1.8	18.7	15.3	0.10	0.06	
Oat fodder	26.6	2.6	1.9	16.9	14.4	0.10	0.09	27.0
Orchard-grass pasture	23.9	4.3	2.2	12.1	10.5	0.14	0.12	26.6
Peas, field	17.3	3.5	2.9	12.2	10.6	0.24	0.05	
Peas and oats	22.5	3.2	2.4	14.3	12.2	0.17	0.07	
Rye fodder	22.3	2.6	2.1	16.3		0.08	0.07	
Rye pasture	19.7	5.4	4.0	13.2	11.5	0.13	0.10	
Soybeans, all analyses	24.0	4.1	3.2	15.2	12.9	0.26	0.07	37.8
Sudan grass, pasture	21.6	3.3	2.4	14.3	12.2	0.12	0.10	21.5
Timothy pasture	23.9	4.7	3.5	15.4	13.1	0.14	0.09	24.2
Timothy in bloom	32.0	2.8	1.5	20.0	16.6	0.08	0.07	
Vetch, hairy	18.2	4.2	3.5	12.3		0.23	0.07	
Vetch and wheat fodder	29.7	3.4	2.5	20.1				
Wheat fodder	31.9	2.7	1.5	18.5		0.05	0.07	20.2

TABLE B

The Morrison Feeding Standard for Dairy Cattle *

	Requirements per Head Daily							
	Digestible Protein pounds	Total Digestible Nutrients pounds	Calcium		Phosphorus		Carotene, mg.	Net Energy, therms
			Grams	Pound	Grams	Pound		
1 Dairy cows								
A. For maintenance per head daily								
700-lb cow	0.44–0.48	5.1–5.8	7.0	0.015	7.0	0.015	42	4.1–4.6
750-lb cow	0.47–0.51	5.4–6.2	7.5	0.017	7.5	0.017	45	4.4–4.9
800-lb cow	0.49–0.54	5.8–6.5	8.0	0.018	8.0	0.018	48	4.6–5.2
850-lb cow	0.52–0.56	6.1–6.9	8.5	0.019	8.5	0.019	51	4.9–5.5
900-lb cow	0.55–0.59	6.4–7.2	9.0	0.020	9.0	0.020	54	5.1–5.8
950-lb cow	0.57–0.62	6.7–7.6	9.5	0.021	9.5	0.021	57	5.4–6.1
1000-lb. cow	0.60–0.65	7.0–7.9	10.0	0.022	10.0	0.022	60	5.6–6.3
1050-lb cow	0.63–0.68	7.3–8.3	10.5	0.023	10.5	0.023	63	5.8–6.6
1100-lb. cow	0.65–0.71	7.6–8.6	11.0	0.024	11.0	0.024	66	6.1–6.9
1150-lb cow	0.68–0.73	7.9–9.0	11.5	0.025	11.5	0.025	69	6.3–7.2
1200-lb cow	0.70–0.76	8.2–9.3	12.0	0.026	12.0	0.026	72	6.6–7.4
1250-lb. cow	0.73–0.79	8.5–9.6	12.5	0.027	12.5	0.027	75	6.8–7.7
1300-lb cow	0.75–0.82	8.8–10.0	13.0	0.029	13.0	0.029	78	7.0–8.0
1350-lb cow	0.78–0.84	9.1–10.3	13.5	0.030	13.5	0.030	81	7.3–8.2
1400-lb cow	0.80–0.87	9.4–10.6	14.0	0.031	14.0	0.031	84	7.5–8.5
1450-lb. cow	0.83–0.90	9.7–11.0	14.5	0.032	14.5	0.032	87	7.7–8.8
1500-lb. cow	0.85–0.92	10.0–11.3	15.0	0.033	15.0	0.033	90	8.0–9.0
1550-lb. cow	0.88–0.95	10.2–11.6	15.5	0.034	15.5	0.034	93	8.2–9.3
1600-lb. cow	0.90–0.98	10.5–11.9	16.0	0.035	16.0	0.035	96	8.4–9.6
1650-lb. cow	0.93–1.00	10.8–12.3	16.5	0.036	16.5	0.036	99	8.7–9.8
1700-lb cow	0.95–1.03	11.1–12.6	17.0	0.037	17.0	0.037	102	8.9–10.1
1750-lb. cow	0.98–1.06	11.4–12.9	17.5	0.039	17.5	0.039	105	9.1–10.3
1800-lb cow	1.00–1.08	11.7–13.2	18.0	0.040	18.0	0.040	108	9.3–10.6
B For milk production per pound of milk. (To be added to allowance for maintenance.)								
For 3.0% milk	0.036–0.043	0.26–0.28	1.0	0.0022	0.75	0.0017		0.24–0.26
For 3.5% milk	0.038–0.046	0.28–0.30	1.0	0.0022	0.75	0.0017		0.26–0.28
For 4.0% milk	0.041–0.049	0.31–0.32	1.0	0.0022	0.75	0.0017		0.29–0.30
For 4.5% milk	0.044–0.052	0.33–0.35	1.0	0.0022	0.75	0.0017		0.31–0.32
For 5.0% milk	0.046–0.056	0.35–0.37	1.0	0.0022	0.75	0.0017		0.33–0.35
For 5.5% milk	0.049–0.059	0.38–0.40	1.0	0.0022	0.75	0.0017		0.35–0.37
For 6.0% milk	0.052–0.062	0.40–0.42	1.0	0.0022	0.75	0.0017		0.37–0.39
For 6.5% milk	0.054–0.065	0.42–0.45	1.0	0.0022	0.75	0.0017		0.39–0.41
C. Additional allowance for last 2 to 3 months of pregnancy (To be added to allowances for maintenance and allowance for milk produced.)								
Small cow	0.50–0.55	5.0–5.5	10.4	0.023	6.4	0.014	24	4.3–4.7
1000-lb. cow	0.55–0.60	5.5–6.0	13.0	0.029	8.0	0.018	30	4.7–5.1
Large cow	0.65–0.70	6.5–7.0	15.6	0.034	9.6	0.021	36	5.5–6.0

* These data are taken by the special permission of the Morrison Publishing Co., Ithaca, New York, from *Feeds and Feeding*, 21st edition, by F B Morrison.

TABLE B (*Continued*)

The Morrison Feeding Standard for Dairy Cattle

	Requirements per Head Daily								
	Dry Matter pounds	Digestible Protein pounds	Total Digestible Nutrients, pounds	Calcium		Phosphorus		Carotene mg	Net Energy, Therms
				Grams	Pound	Grams	Pound		
2 Growing dairy cattle									
Weight 60 lb	0 8- 1 1	0 20-0 25	1 0- 1 3	5	0 011	4	0 009	6	1 2- 1 6
Weight 100 lb	1 6- 2 6	0 30-0 40	1 4- 2.1	8	0 018	6	0 013	6	1 5- 2 3
Weight 150 lb	3 2- 4 6	0 43-0 52	2 5- 3 5	12	0 026	8	0 018	9	2 5- 3 5
Weight 200 lb	4 7- 6 4	0 53-0 62	3 5- 4 5	16	0 035	11	0 024	12	3 3- 4 5
Weight 300 lb	7 2- 9 0	0 67-0 77	5 0- 6 0	18	0 040	13	0 029	18	4 5- 5 5
Weight 400 lb.	9 1-11 4	0 76-0 87	6 0- 7 0	20	0 044	15	0 033	24	5 4- 6 3
Weight 500 lb	10 7-13 0	0 81-0 92	6 9- 8 1	19	0 042	15	0 033	30	6 1- 7 2
Weight 600 lb	12 4-14 7	0 84-0 95	7 9- 9 1	18	0 040	15	0 033	36	7 0- 8 0
Weight 700 lb	14 2 16 5	0 87-0 98	8 6- 9 9	17	0 037	15	0 033	42	7 4- 8 5
Weight 800 lb	15 9-18 3	0 90-1 00	9 2 10 6	16	0 035	15	0 033	48	7 9- 9 1
Weight 900 lb	17 3-19 7	0 93-1 03	9 8-11 2	16	0 035	15	0 033	54	8 4- 9 6
Weight 1000 lb	18 6-21 0	0 95-1 05	10 3-11 7	15	0 033	15	0 033	60	8 9-10 1
3 Mature dairy bulls heavy *service*									
Weight 1200 lb	14 7-16 3	1 02-1 12	9 8-10 8	12	0 026	12	0 026	72	8 5- 9 5
Weight 1400 lb.	17 2-19 0	1 19-1 31	11 0-12 2	14	0 031	14	0 031	84	9 6-10 6
Weight 1600 lb	18 6-20 6	1 28-1 42	12 3 13 5	16	0 035	16	0 035	96	10 7-11 9
Weight 1800 lb	20 4-22 6	1 40-1 54	13 5-14 9	18	0 040	18	0 040	108	11 8-13 0
Weight 2000 lb	22 0-24 2	1 50-1 66	14 8-16 4	20	0 044	20	0 044	120	12 9-14 3
Weight 2200 lb.	24 1-26 7	1 65-1 83	16 0-17 8	22	0 049	22	0 049	132	14 1-15 5
Weight 2400 lb.	26 3-29 1	1 83-2 00	17 4-19 2	24	0 053	24	0 053	144	15 1-16 7
Weight 2600 lb	28 5-31 5	1 96-2 16	18 5-20 5	26	0 057	26	0 057	156	16 2 18 0

TABLE C

Recommended Daily Allowances for Dairy Cattle **

(Based on Air-Dry Feed Containing 90 Per Cent Dry Matter)

Body Weight, pounds	Expected Gain		Daily Allowances per Animal *						
	Small Breeds, pounds	Large Breeds, pounds	Total Feed, pounds	Digestible Protein, pounds	T.D.N., pounds	Calcium, grams	Phosphorus, grams	Carotene, milligrams	Vitamin D, I.U.
Normal Growth of Dairy Heifers									
50	0.5	..	0.9	0.20	1.0	4	3	6 †	200
100	1.0	0.8	2.0	0.40	2.0	8	6	6	400
150	1.3	1.4	4.0	0.50	3.0	12	8	9	600
200	1.4	1.6	6.0	0.60	4.0	16	11	12	800
400	1.2	1.8	11	0.80	6.5	20	15	24	‡
600	0.8	1.4	15	0.85	8.5	18	15	36	
800	1.1	1.2	19	0.90	10.0	16	15	48	
1000	...	1.3	22	0.95	11.0	15	15	60	
1200	..	1.2	24	1.00	12.0	15	15	72	
Maintenance of Mature Cows §									
800	..	...	14	0.50	6.8	8	8	48	‡
1000	...	...	16	0.60	8.0	10	10	60	
1200	..	..	18	0.70	9.2	12	12	72	
1400	.	..	21	0.80	10.5	14	14	84	
1600	...	..	23	0.87	11.4	16	16	96	
Reproduction (Add to Maintenance During Last 2 to 3 Months)									
	2.0	*2.0*	*8.0*	*0.60*	*6.0*	*12*	*7*	*30*	‡
Lactation (Add to Maintenance for Each Pound of Milk)									
	3.0% fat		..	0.040	0.28	1	0.7	‖	‖
	4.0% fat		..	0.045	0.32	1	0.7		
	5.0% fat		..	0.050	0.37	1	0.7		
	6.0% fat		..	0.055	0.42	1	0.7		
Maintenance of Breeding Bulls									
1200	..	...	18	1.00	10.3	12	12	72	
1600	...	...	22	1.20	12.9	16	16	96	‖
2000	...	...	27	1.45	15.6	20	20	120	
2400	..	...	31	1.60	18.2	24	24	144	

* Thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, and vitamin K are synthesized by bacteria in the rumen, and it appears that adequate amounts of these vitamins are furnished by a combination of rumen synthesis and natural feedstuffs. Manganese, iron, copper, and cobalt are clearly essential, but the amounts needed are not known. For growth, 0.6 gm. magnesium is needed per 100 pounds of body weight.

† Calves should receive colostrum the first few days after birth, as a source of vitamin A and other essential factors.

‡ While vitamin D is known to be required, the data are inadequate to warrant specific figures for older growing animals and for maintenance, reproduction, and lactation. The vitamin D allowance has been increased from 300 to the present 400 I.U. per 100 pounds body weight to provide a safety margin comparable to that of other nutrients

§ When calculating the allowances for lactating heifers that are still growing, it is recommended that the figure for *growth* rather than *maintenance* be used.

‖ When adequate amounts of vitamins A and D are fed for normal reproduction, extra amounts will probably not stimulate milk production but will increase the vitamin content of the milk.

** Recommended Nutrient Allowances for Dairy Cattle, Natl. Research Council, 1950.

TABLE D

Recommended Nutrient Content of Rations for Dairy Cattle *
(Based on Air Dry Feed Containing 90 Per Cent Dry Matter)

Weight, pounds	Average Age: Small Breeds, months	Average Age: Large Breeds months	Total Daily pounds	Feed Per Cent of Weight per cent	Digestible Protein Per Cent	T D N per cent	Calcium per cent	Phosphorus, per cent	Carotene mg /lb	Vitamin D I U per lb.
			Allowances as Per Cent of Ration or Amount per Pound of Feed							
Normal Growth of Dairy Heifers										
50	Birth		0.9	1.6	22	110	0.98	0.3		220
100	2.3	0.6	2.0	2.0	20	100	0.88	0.66	3.0	200
150	3.7	2.0	4.0	2.7	12.5	5	0.66	0.44	2.2	150
200	4.8	3.1	6.0	3.0	10.0	67	0.58	0.40	2.0	130
400	10.0	6.7	11	2.8	7.3	59	0.40	0.30	2.2	
600	17.2	10.8	15	2.7	5.7	57	0.26	0.22	2.4	
800	28	16.0	19	2.5	4.7	53	0.19	0.17	2.5	
1000		22.0	22	2.2	4.3	50	0.15	0.15	2.7	
1200		36	24	2.0	4.2	50	0.14	0.14	3.0	
Maintenance of Mature Cows										
800			14	1.8	3.6	50	0.13	0.13	3.4	
1000			16	1.6	3.7	50	0.14	0.14	3.8	
1200			18	1.5	3.9	50	0.15	0.15	4.0	
1400			21	1.4	3.8	50	0.15	0.15	4.0	
1600			23	1.3	3.8	50	0.15	0.15	4.1	
Maintenance of Breeding Bulls										
1200			18	1.5	5.6	58	0.15	0.15	3.9	
1600			22	1.4	5.5	58	0.16	0.16	4.4	
2000			27	1.2	5.4	58	0.16	0.16	4.4	
400			31	1.3	5.2	58	0.17	0.17	4.6	

* Recommended Nutrient Allowances for Dairy Cattle, Natl. Research Council, 1950.

TABLE E

Space Required for Storing Various Feeds *

Material	Weight per Cubic Foot in Pounds	Cubic Feet per Ton
Hay, loose in shallow mows	4	512
Hay, loose in deep mows	5	400
Hay, baled loose	10	200
Hay, baled tight	25	80
Hay, chopped long cut	8	250
Hay, chopped short cut	12	167
Straw, loose	4	512
Straw, baled	12	167
Silage, shallow	30	67
Silage, deep	50	40
Barley, 48 lb. per bu.	39	51
Corn, ear, 70 lb. per bu.	56	36
Corn, shelled, 56 lb. per bu.	45	44
Corn, cracked or corn meal, 50 lb. per bu.	40	50
Corn-and-cob meal, 45 lb. per bu.	36	56
Oats, 32 lb. per bu.	26	77
Oats, ground, 22 lb. per bu.	18	111
Oats, middlings, 48 lb. per bu.	39	51
Rye, 56 lb. per bu.	45	44
Wheat, 60 lb. per bu.	48	42
Soybeans, 62 lb. per bu.	50	40
Most concentrates	45	44

* Adapted from *Hoard's Dairyman* (1951).

TABLE F *

Average Weights of Different Feeding Stuffs

Feeding Stuff	One Quart Weighs	One Pound Measures
Barley meal	1 1 lb	0 9 qt.
Barley, whole	1 5 lb	0 7 qt.
Brewers' dried grains	0 6 lb	1 7 qt
Corn and-cob meal	1 4 lb	0 7 qt
Corn bran	0 5 lb	2 0 qt
Corn meal	1 5 lb	0 7 qt.
Corn, whole	1 7 lb	0 6 qt
Cottonseed meal	1 5 lb	0 7 qt
Distillers' grains, dried	0.5–0 7 lb	1 0–1 4 qt
Germ-oil meal	1 4 lb	0 7 qt
Gluten feed	1 3 lb	0 8 qt.
Gluten meal	1 7 lb	0 6 qt
Hominy meal	1 1 lb	0 9 qt
Linseed meal (n p)	0 9 lb	1 1 qt
Linseed meal (o p)	1 1 lb	0 9 qt.
Malt sprouts	0 6 lb	1 7 qt
Oats, ground	0 7 lb	1 4 qt
Oats whole	1 0 lb	1 0 qt
Rye meal	1 5 lb	0 7 qt
Rye, whole	1 7 lb	0 6 qt
Wheat bran	0 5 lb	2 0 qt
Wheat, ground	1 7 lb	0 6 qt
Wheat middlings, flour	1 2 lb	0 8 qt.
Wheat middlings, standard	0 8 lb	1 3 qt
Wheat, whole	1 9 lb	0 5 qt

Note 2150 42 cubic inches equal one bushel, 67 2 cubic inches equal one quart dry measure

* *Farmers' Bul* 222

TABLE G

Average Weight per Cubic Foot and the Total Quantity of Settled Silage from the Top to Various Depths *

Depth of Settled Silage, feet	Average Weight per Cubic Foot †		Total Quantity of Settled Silage, from the Top to the Depth Indicated, in Silos Having a Diameter of ‡					
	Silage	Dry Matter	10 Feet	12 Feet	14 Feet	16 Feet	18 Feet	20 Feet
	Pounds	Pounds	Tons	Tons	Tons	Tons	Tons	Tons
1	17 7	4 89	0 7	1 0	1 4	1 8	2 2	2 8
2	23 5	6 49	1 8	2 6	3 6	4 7	6 0	7 4
3	26 9	7 43	3 2	4 6	6 2	8 1	10 3	12 7
4	29 5	8 15	4 7	6 7	9 1	11 9	15 0	18 5
5	31 6	8 73	6 3	8 9	12 1	15 9	20 1	24 8
6	33 3	9 20	7 9	11 3	15 4	20 1	25 5	31 4
7	34 7	9 59	9 6	13 8	18 7	24 4	31 0	38 3
8	36 0	9 95	11 4	16 3	22 2	29 0	36 7	45 3
9	37 1	10 25	13 2	18 9	25 7	33 6	42 6	52 5
10	38 1	10 53	15 0	21 6	29 4	38 3	48 6	59 9
11	39 0	10 78	16 9	24 3	33 0	43 1	54 7	67 4
12	39 8	11 00	18 8	27 0	36 8	48 0	60 9	75 1
13	40 6	11 22	20 8	29 8	40 6	53 0	67 2	82 8
14	41 2	11 38	22 7	32 6	44 4	58 0	73 5	90 7
15	41 8	11 55	24 7	35 5	48 3	63 1	79 9	98 6
16	42 4	11 72	26 7	38 4	52 2	68 2	86 4	106 6
17	43 0	11 88	28 7	41 3	56 2	73 4	93 0	114 7
18	43 5	12 02	30 8	44 2	60 2	78 6	99 6	122 8
19	43 9	12 13	32 8	47 2	64 2	83 8	106 2	131 0
20	44 3	12 24	34 9	50 1	68 2	89 1	112 8	139 2
21	44 7	12 35	36 9	53 1	72 3	94 4	119 6	147 5
22	45 1	12 46	39 0	56 1	76 4	99 8	126 3	155 8
23	45 5	12 57	41 1	59 1	80 5	105 1	133 1	164 2
24	45 8	12 65	43 2	62 1	84 6	110 5	139 9	172 6
25	46 1	12 74	45 3	65 2	88 7	115 9	146 7	181 0
26	46 4	12 82	47 4	68 2	92 9	121 3	153 6	189 5
27	46 7	12 90	49 6	71 3	97 0	126 8	160 5	198 0
28	46 9	12 96	51 7	74 4	101 2	132 2	167 4	206 5
29	47 2	13 04	53 8	77 4	105 4	137 7	174 3	215 1
30	47 4	13 10	56 0	80 5	109 6	143 1	181 2	223 6
31	47 7	13 18	58 1	83 6	113 8	148 6	188 1	232 2
32	47 9	13 23	60 2	86 7	118 0	154 1	195 1	240 8
33	48 1	13 29	62 4	89 8	122 2	159 6	202 0	249 3
34	48 3	13 35	64 5	92 8	126 4	165 1	209 0	257 9
35	48 5	13 40	66 7	96 0	130 6	170 6	216 0	266 6
36					134 8	176 1	222 9	275 2
37					139 0	181 6	229 9	283 8
38					143 3	187 1	236 9	292 4
39					147 5	192 6	243 8	301 0
40					151 7	198 2	250 8	309 6
41						203 7	257 8	318 2
42						209 2	264 8	326 8
43						214 7	271 7	335 4
44						220 2	278 7	344 0
45						225 7	285 7	352 6
46							292 6	361 3
47							299 6	369 9
48							306 6	378 5
49							313 5	387 1
50							320 5	395 7

* Based on the data for 4 Beltsville silos in which the silage contained 27 63 per cent of dry matter

† The average weight per cubic foot for all silage above the depth indicated

‡ The Beltsville data indicate that the table of silage weights can be used without change for silage made from well-eared corn that was finely chopped when put in the silo, if it was cut when slightly dented to well dented and before it is fully dented and hard. Cut at this stage, silage will normally contain 70 to 74 per cent of moisture or 30 to 26 per cent of dry matter

For corn silage differing from the above, the Beltsville data indicate that the following corrections should be used

(a) If the corn is well eared but immature, add 5 per cent to the figures in the table If it has only a fair number of ears, deduct 5 per cent and if it has few ears or none deduct 10 per cent.

(b) If the corn contains 31 to 33 per cent of dry matter (almost fully dented), deduct 5 to 10 per cent.

(c) If the corn contains 34 to 36 per cent of dry matter (fully dented and hard), deduct 15 to 20 per cent

(d) If the corn is cut in ¼- to ¾-inch lengths or longer, deduct 5 per cent.

(From U S D A Circ. 603.)

TABLE H

Suggested Rates for Charging for Custom Work

Farm Operation	College Farm Service Cost *	Suggested Operating Margin, per cent	Suggested Range in Actual Charge (Actual charge depends upon individual conditions favorable or unfavorable.)
Tillage			
Plowing: 2-bottom plow	$2.70 per acre	25	$3.25 to $4.00 per acre
3-bottom plow	2.30 per acre	25	2.75 to 3.50 per acre
Disk harrow, 10-foot tandem	0.92 per acre	25	1.15 to 1.40 per acre
Drag harrow 20 foot	0.61 per acre	20	0.75 to 0.85 per acre
Packing, double-gang corrugated roller	0.83 per acre	30	1.00 to 1.25 per acre
Planting			
Drill small grain 10½ foot	0.97 per acre	25	1.20 to 1.45 per acre
Fertilizer drill, grain, and fertilizer 10½ foot	1.45 per acre	30	1.80 to 2.15 per acre
Seeding alfalfa, clover grasses, cultipacker seeder	0.92 per acre	30	1.15 to 1.40 per acre
Plant, row crop, drill. 2 row	1.45 per acre	20	1.80 to 2.15 per acre
4 row	0.92 per acre	20	1.15 to 1.40 per acre
Plant, check row 4 row	1.35 per acre	25	1.70 to 2.00 per acre
4 row and fertilizer	1.60 per acre	25	2.00 to 2.40 per acre
Cultivation			
Weeder, 4 row	0.60 per acre	20	0.75 to 0.90 per acre
Rotary hoe 2 row	0.92 per acre	20	1.15 to 1.40 per acre
Cultivate shovel or sweeps 2 row	1.30 per acre	25	1.60 to 2.00 per acre
4 row	1.00 per acre	25	1.25 to 1.50 per acre
Harvesting			
Corn picking, 2 row	3.95 per acre	50	5.00 to 6.00 per acre
Hauling from field, elevating and binning	0.05 per bu.	35	0.06 to 0.07 per bu.
Combining, direct, or pickup	3.95 per acre	50	5.00 to 6.00 per acre
Windrowing	1.60 per acre	40	2.00 to 2.40 per acre
Forage harvesting corn or sorghums field cut	6.10 per acre	50	7.50 to 9.00 per acre
grass and legume field cut	6.10 per acre	50	7.50 to 9.00 per acre
Haul, elevate, or blow and pack silage	1.25 per ton	40	1.50 to 1.90 per ton
Shell corn	0.05 per bu.	35	0.06 to 0.07 per bu.
Haying			
Mowing	1.25 per acre	25	1.50 to 1.80 per acre
Raking hay	0.92 per acre	25	1.15 to 1.40 per acre
Loading and hauling loose hay	2.80 per acre	20	3.50 to 4.20 per acre
Baling, automatic field bale, including tie	3.10 per ton †	40	3.90 to 4.60 per ton
Pickup, haul, and store bales	2.60 per ton	30	3.25 to 3.90 per ton
Processing			
Grind shelled corn	0.09 per bu.	25	0.11 to 0.13 per bu.
Grind ear corn	0.10 per bu.	20	0.12 to 0.15 per bu.
Grind cobs	0.28 per cwt.	40	0.35 to 0.42 per cwt.
Grind oats or small grains	0.08 per bu.	30	0.10 to 0.12 per bu.
Fertilizing			
Load, haul, and spread manure ‡	1.75 per ton	35	2.20 to 2.60 per ton
Spread commercial fertilizer broadcast	1.30 per acre	30	1.60 to 1.95 per acre
Spraying			
Spray 2,4-D (corn or flat work includes 2,4-D)	2.10 per acre	30	2.60 to 3.15 per acre
Spray corn borer (no materials furnished)	0.50 per acre	30	0.65 to 0.75 per acre
Spray DDT *fly control in buildings and around lots, men (no materials)*	2.95 per hour	30	3.60 to 4.50 per hour
Miscellaneous			
Clip pastures	1.15 per acre	30	1.45 to 1.70 per acre
Cut cornstalks, rotary cutter	2.10 per acre	25	2.60 to 3.15 per acre
Bore-post holes	0.22 each	30	0.27 to 0.33 each

* Based on cost accounting experience. (Includes depreciation, interest on investment, housing, federal excise taxes, repairs, servicing, fuel, and labor.)

† 60-pound bales, 32 to 34 bales per ton.

‡ Average length of haul, 2 miles one way.

(From *Iowa Farm Science*, Vol. 6, No. 7.)

TABLE I

Gestation Table for Dairy Cattle

(Computed from Data from *J. Dairy Sci.*, 35: 179)

Service Date	Date Due to Calve: Ayr., Hol., Jer. (278 days)	Guernsey (283 days)	Brown Swiss (288 days)
Jan. 1	Oct. 6	Oct. 11	Oct. 16
Jan. 15	Oct. 20	Oct. 25	Oct. 30
Feb. 1	Nov. 6	Nov. 11	Nov. 16
Feb. 15	Nov. 20	Nov. 25	Nov. 30
Mar. 1	Dec. 4	Dec. 9	Dec. 14
Mar. 15	Dec. 18	Dec. 23	Dec. 28
Apr. 1	Jan. 4	Jan. 9	Jan. 14
Apr. 15	Jan. 18	Jan. 23	Jan. 28
May 1	Feb. 3	Feb. 8	Feb. 13
May 15	Feb. 17	Feb. 22	Feb. 27
June 1	Mar. 6	Mar. 11	Mar. 16
June 15	Mar. 20	Mar. 25	Mar. 30
July 1	Apr. 5	Apr. 10	Apr. 15
July 15	Apr. 19	Apr. 24	Apr. 29
Aug. 1	May 6	May 11	May 16
Aug. 15	May 20	May 25	May 30
Sept. 1	June 6	June 11	June 16
Sept. 15	June 20	June 25	June 30
Oct. 1	July 6	July 11	July 16
Oct. 15	July 20	July 25	July 30
Nov. 1	Aug. 6	Aug. 11	Aug. 16
Nov. 15	Aug. 20	Aug. 25	Aug. 30
Dec. 1	Sept. 5	Sept. 10	Sept. 15
Dec. 15	Sept. 19	Sept. 24	Sept. 29

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